Alternative Fleet Architecture Design

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Foreword

Long experience has conditioned us to equate the preparation of the U.S. Armed Forces for the future with the process of "modernization," that is, building updated versions, or new generations, of the equipment that our forces currently use. That experience is increasingly outdated. Modernization permits occasional incorporation of advances in technology, based mainly on military research and development, in view of actual and anticipated changes in enemy capabilities. The U.S. Navy has conformed to the modernization model as closely as any Service in planning and building the next generation of ships and aircraft.

There was an understandable logic for this approach during the Cold War when we faced an adversary whose capabilities and operations were well understood. High priority in fleet development was placed on a steady, evolutionary improvement to keep pace with a relatively well understood, steadily evolving adversary. This is no longer the case. In planning for the fleet of the future, we must take into account that we are transiting from one global security era to a future era that is more dynamic and consequently less predictable than the old one. This compels the United States to be prepared to respond much more quickly than in the past to unpredictable changes and argues against a planning and programming strategy that is evolutionary in nature.

A related challenge is that most of the potential future threats we face are complex, i.e., scalable and diverse. They come largely from groups of loosely connected networks of adversaries whose behavior is difficult to predict. The United States, on the other hand, presents an adversary with a great deal of predictability, particularly in the area of naval capabilities. Ships take a long time to build, and once built, they tend to have capabilities and operational patterns that are locked-in and well known to our potential adversaries.

In developing and using forces, including the future U.S. naval fleet, the ability to complicate warfare for an enemy is an important consideration. In maritime operations, factors that can complicate the operational problems facing an adversary include: large numbers of combat entities that the enemy must deal with; a great variety of platforms with which the enemy must contend; speed and maneuverability; different combinations of forces; distribution of forces across large areas; and uncertainty as to the mission and capabilities of a given platform.

The U.S. Navy can design its future fleet platform architecture with these principles in mind. An ***alternative fleet architecture design*** and three examples of future fleet platform architectures are presented in this report. These alternative fleet platform architectures make use of modularity for tactical adaptability to unforeseen crises and lower unit costs to increase the numbers of ships in the fleet.

In addition, the alternative fleet architectures take advantage of the power of networking individual platforms into a system whose capabilities are far greater than the sum of its separate parts. This network is characterized by dispersed forces that develop a high level of shared battlespace awareness. In turn, shared awareness within the fleet can be exploited to achieve strategic, operational, and tactical objectives according to the commander's intent. The network

can operate with increased speed and synchronization and is capable of achieving massed effects without the physical massing of forces required in the past.

The U.S. Navy has the opportunity to launch itself on a trajectory that will deliver a quantum leap ahead in capabilities against an array of enemies—from the large highly developed competitor to the small but determined asymmetric adversary.

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Executive Summary

This report calls into question the viability of the longstanding logic of naval force building. It provides a description of the opportunities that rapid advances in technology and organizational effectiveness offer the U.S. Navy as it looks to a demanding future. Most important, it provides an ***alternative fleet architecture design*** that incorporates the three broad elements of the Department of Defense's transformation strategy.

- Implementing network-centric warfare (NCW) as the new theory of war for the information age.

- Broadening the capabilities base, creating coherence between force building and force operations, and addressing a broadening threat base.

- Responding to falling barriers to competition by establishing a new competitive model and new metrics.

The report sets out to capture the spectrum of threats and the budgetary limitations with which a future Navy must cope; establish design principles based on meeting those future challenges and on taking advantage of rapid advances in technology and organizational effectiveness; and propose an alternative to the programmed future fleet architecture.

The analysis in **Chapter 2** (Strategic Context) describes the changed security environment, which mandates a fleet that both broadens the Navy's capability to preserve its strategic advantage and makes it better suited for intervention against asymmetric threats.

Chapter 3 (Budgetary Challenges) analyzes the Navy's shipbuilding program and budget and demonstrates that it is based on optimistic, indeed risky, fiscal projections. An alternative, more realistic shipbuilding program needs to be developed to avoid further shrinking of the fleet and diminishing capability.

Taking these two findings – the changed security environment and uncertain resources – as imperatives for action, this report proposes an alternative: a fleet architecture built on new core design principles. **Chapter 4** (Technology Opportunities) reviews the opportunities to be gained by exploiting recent technological developments. **Chapter 5** (Alternative Fleet Architecture Design) lays out four principles that take advantage of the foregoing analyses and guide the design of the ***alternative fleet architecture***: complexity, smaller ships with improved payload fraction, network-centric warfare, and modularity. These design principles will help the Navy and its defense industry partners create a future U.S. fleet that is dominant across a broad spectrum of missions. This includes conducting ***joint expeditionary operations*** in the "gap" and maintaining the United States' vital ***strategic advantage*** in the global commons of ocean (surface and subsurface), air, space, and cyber space. This future fleet will also be capable of influencing the future competitive environment for U.S. advantage.

With this spectrum of missions in mind, examples of alternative fleet architectures are developed and presented in **Chapter 6**. They and the U.S. Navy's programmed fleet are evaluated against two planning and operational challenges the Navy will face:

- The need to participate in ***joint expeditionary operations***. These types of operations have characterized many U.S. military operations conducted over the past 15 years. In the future, they may be conducted against either states or non-state actors, but in either case would be against asymmetric, irregular, and elusive enemies with an accent much more on the littoral areas than on the open ocean.

- The need to maintain the ***strategic advantage*** the Navy has developed in the global commons. The goal may be to dissuade a would-be strategic challenger or, at a minimum, to prevent a capable adversary from denying us the ability to operate in any part of the commons where we need to be.

The analysis presented in the body of this report shows that the ***future naval fleet platform architecture*** need not be designed to optimize its performance against asymmetric challenges at the expense of its ability to confront a potential adversary capable of traditional high intensity conflict. Indeed, designing a fleet architecture composed of large numbers of manned and unmanned systems, networked together, provides coherence between building the force and operating the force against *both* challenges. Such a fleet would be able to bring force to bear more rapidly and withstand enemy attack more effectively than the fleet architecture currently programmed by the Navy.

As mentioned, the alternative fleet platform architecture has been guided by four major design principles.

Complexity: The alternative architecture has been designed to complicate both an adversary's force planning and operations planning. In maritime operations, characteristics of naval forces that complicate planning, decision making, and operational problems facing an adversary include:

- Large numbers of platforms that the enemy must find, track, and target;

- Great variety of forces with which the enemy must contend;

- Fast, agile, low-signature platforms;

- Different combinations of forces, quickly assembled and reassembled;

- Distribution of forces across large areas for the enemy to search and cover;

- Platforms designed to foster ambiguity concerning their missions and capabilities; and

- Constant experimentation with new operational concepts, thereby creating uncertainty among enemies as to how the fleet will operate.

Smaller Ships and Improved Payload Fraction: Advances in shipbuilding are making it possible for ever smaller ships to be seaworthy in the spectrum of conditions that combat fleets encounter. Moreover, promising research and development on smaller weapons with high precision and enhanced terminal effects and on smaller sensor packages is making it possible to package capabilities onto small ships that have been reserved to large ships up to now. Because of lightweight structural materials, innovative design, and sharply reduced manning, ships can be made faster and more maneuverable while payload fraction can increase from less than 10% to over 30%.

Network-Centric Warfare: Added to the foregoing is the power that networking adds to a fleet. Advances in information technologies make it possible to network dispersed components of a fleet so that the total power of the fleet greatly exceeds the sum of the capabilities of its individual components.

Modularity: The alternative fleet platform architecture incorporates a generous mix of ship capabilities. The ships make extensive use of modularity to maintain the ability to adapt to changing strategic or operational challenges. Separating the sensor and weapon suites from the hull permits the Navy to incorporate new technology into the module without taking the ship out of service to do so. The alternative architecture also leverages the growing capabilities of unmanned vehicles (UVs).

The three alternative fleet platform architecture examples presented in **Chapter 6** have been developed using a new competitive model, one which creates overmatching complexity at scale, creates and preserves options, achieves higher learning rates, and employs higher transaction rates and faster cycle times. The new competitive model is also an integral element of a broader strategic approach to cost.

Since predicting the future is all but impossible, the new force building logic manages uncertainty by creating a breadth of capabilities appropriate across a broad range of alternative futures. This new logic is applicable to both force building and force operations.

Implementation of the alternative fleet architecture should start now and should target option generation, short construction time, and technology insertion. The alternative further provides an opportunity to reinvigorate the shipbuilding industrial base. The many smaller ships, manned and unmanned, in the alternative fleet architecture could be built in more shipyards and would be relevant to overseas markets. The potential longevity of the existing fleet will sustain existing shipyards as they move into building smaller ships more rapidly in this broader market and more competitive environment. The shipyards would develop a competence, broad relevance, and operate in an environment driven by market imperatives instead of a framework of laws that frustrates market forces.

As the new ships enter service and the fleet has the opportunity to experiment with new operational concepts (expanded network-centric warfare in particular) existing ships can be retired sooner to capture operations savings. At this point, the sooner the existing fleet is retired, the sooner the benefits of the ***alternative fleet architecture design*** will accrue.

1. Introduction

The challenges the U.S. Armed Forces will face over the next several decades are likely to be complex in nature and also extremely dangerous. The major security threats to the United States and our allies are expected to come largely from loosely connected transnational groups, to include international terrorist organizations whose members will be difficult to detect and track, whose capabilities will not always be fully understood, and whose behavior is hard to predict. The nature of future threats to U.S. interests from hostile regional powers and rogue states is also likely to be characterized by complexity. When attacked by terrorists, regional powers, or rogue states in the future, the U.S. Navy can expect to face a variety of enemy capabilities including mines, quiet submarines, shore-based missiles, and numerous small craft, that, taken together, present a highly complex challenge.

In comparison, the United States has traditionally presented adversaries with a great deal of predictability in its naval forces. We take a long time to design and build our ships and, once built, they tend to remain in the fleet for many years with capabilities that are more or less locked in and well known to our adversaries. As the U.S. Navy continues the process of transformation to prepare for future challenges, one of its key design principles, as it develops the ***future fleet platform architecture,*** ought to be to ***create complexity for the enemy***. Quite simply, the Navy's aim should be to complicate planning and actual operations for our adversaries, thereby giving the United States a powerful advantage in future conflicts. In the maritime domain, factors that can complicate the force building and operational problems facing an adversary include:

- Large numbers of platforms that the enemy must track and target;
- Great variety of forces with which the enemy must contend;
- Fast, agile, low-signature platforms;
- Different combinations of forces, quickly assembled and reassembled;
- Distribution of forces across large areas for the enemy to search and cover;
- Platforms designed to foster ambiguity concerning their missions and capabilities; and
- Constant experimentation with new operational concepts, thereby creating uncertainty among enemies as to how we will operate.

A fleet that possesses these qualities can make planning for warfare far more complex and costly for enemy leaders. Specific consequences of the U.S. Navy's ability to present future adversaries with more complexity include: taxing enemy surveillance, tracking, targeting, and weapons allocation; slowing the speed of enemy decision making; delaying the positioning or use of the appropriate enemy forces once decisions are made; making it more difficult for enemy forces to elude detection; isolating and over-matching enemy units; and producing command and control confusion for enemy forces, perhaps even decision overload.

The Navy can design its ***future fleet platform architecture*** with the vital goal of complexity in mind. Examples of alternative future fleet platform architectures with the potential to create this sort of complexity for future adversaries are presented in **Chapter 6**. A fleet with such characteristics will provide a quantum leap ahead in capabilities against a spectrum of enemies ranging from large, highly developed competitors to small but determined asymmetric adversaries. This adaptability is critical. The security environment that is emerging is less stable, more dynamic and consequently less predictable than in the past. It will surely include elements typical of the last dozen years, challenges from hostile states or from non-state actors, e.g. terrorists or insurgents. U.S. interests and security will require continued ***joint expeditionary operations*** as an instrument of U.S. national defense policy.

At the same time, the United States has established a dominant global strategic military position within which naval supremacy is a crucial component. This ***strategic advantage*** can dissuade adventurism and power projection by those tempted and able to mount such challenges. Moreover, it can be used to safeguard the use of the commons, especially the sea lanes, for global commerce. Key to maintaining the United States' strategic advantage is the fleet's ability to operate wherever it needs to operate. This would include, but not be limited to, maintaining the ability to operate in the Western Pacific even if China were to attempt to deny us that freedom. A powerful, survivable U.S. Navy in the Pacific theater is likely to be the most valuable military instrument for convincing China to pursue its regional (and global) interests in ways that do not confront U.S. power or contest the international norms that that power underwrites.

It would be a mistake to design the future fleet with an exclusive focus on either conducting ***joint expeditionary operations*** or maintaining the U.S. ***strategic advantage*** through naval supremacy. Instead, a new approach to naval planning is required that delivers a fleet architecture that is effective in both areas.

The ***alternative fleet architecture design*** described in **Chapter 5** includes four major design principles:

- **Complexity:** As already discussed, through its adherence to the design principle of complexity, the U.S. Navy can complicate planning and actual operations for future adversaries, giving the fleet an important competitive advantage.

- **Smaller Ships and Improved Payload Fractions:** Advances in shipbuilding are making it possible for much smaller ships to be seaworthy across the full spectrum of operations that the future fleet is expected to encounter. Promising research and development (R&D) on weapons and sensors is allowing the Navy to package ever more potent capabilities onto small ships than has been possible in the past, even the recent past. By combining lightweight structural material, innovative design, and sharply reduced manning, a ship's payload fraction can increase from less than 10% to over 30%.

- **Network-centric warfare (NCW):** The rapid increase of networking and the development of enhanced network-centric capabilities is shifting the functionality of the fleet from individual platforms into an architecture through which they are able to work

together more effectively and with much greater shared situational awareness, speed of command, and decision making. A networked fleet delivers capabilities far greater than the sum of the capabilities inherent in its individual platforms. Moreover networks can be reconfigured, adapted, and improved much more rapidly and much more cheaply than a collection of autonomous platforms.

- **Modularity:** Increasing the modularity of the fleet provides additional flexibility and adaptability. By providing naval commanders with the ability to rapidly swap out modules that endow platforms with different capabilities, the fleet can adjust promptly to the wide spectrum of challenges it could face.

In sum, applying the four major design principles of ***complexity***, ***smaller ships and improved payload fractions***, ***networking***, and ***modularity*** to the design of the future fleet architecture will go a long way towards resolving the dilemma of how to prepare for one future without sacrificing the capability to meet the other. It has the added advantage of complicating an enemy's planning by making the character and operations of our fleet less predictable.

The approach to designing a future fleet architecture along the lines described above also has the advantage of positioning the fleet to take advantage of the ***high leverage technology opportunities*** outlined in **Chapter 4**. Growth in processing power and high bandwidth data links continue to expand the capacity of networks. These same trends are expanding the utility of unmanned vehicles to take on the difficult and dangerous tasks of reconnaissance over enemy territory as well as mine detection and neutralization and anti-submarine warfare (ASW) in the littorals. Advances in weapons effects combined with high precision in striking targets mean that lethality once reserved for large platforms can be packaged onto much smaller platforms. Commercial experience in standardized interfaces in lieu of standardized end products provides a growing body of empirical evidence for designing modules that can be swapped on and off a platform promptly. New hull designs are enabling greater seaworthiness, higher speeds, and greater maneuverability of ever smaller naval combatants.

The foregoing description of the ***alternative fleet architecture design*** and the strategic context within which it is applied represent more than an opportunity for the Navy. This approach, or one like it, is an imperative. The currently programmed future fleet architecture is dependent on a sharp growth in funding for shipbuilding and combat aviation. The affordability of the Navy's long-term shipbuilding plan depends on five key assumptions. If one or more of these assumptions do not hold up in the years ahead, the shipbuilding program will not be executable as planned.

- DoD's budget top-line continues to experience the real growth projected through 2011 and beyond, and within that top-line, DoD's procurement budgets grow strongly.

- Supplemental spending bills will largely fund war operations in Iraq and Afghanistan so that money does not have to be pulled out of the core DoD budget for this purpose.

- The Navy continues to receive the share of DoD's overall budget (and procurement budget) that is envisioned by its shipbuilding plan.

- The Navy succeeds in restraining operations and maintenance (O&M) cost growth through base realignment and closure (BRAC) and other measures.

- The Navy successfully controls the over-budget construction costs of its new ships despite sharp cutbacks in R&D.

None of these developments is materializing. Indeed, trends in all five areas are moving in the wrong direction. They are analyzed in detail in **Chapter 3**. Moreover, in part to fund procurements, the Navy is cutting its R&D funding by 25% through FY2009, thereby constraining the ability to suppress cost while preserving capability. As long as the focus is on high unit cost, highly integrated, multi-mission platforms, the Navy will be faced with a fleet design that scales badly. Orders for new ships will shrink, unit price will rise further, and the size of the fleet will continue to decline, further diminishing the Navy's flexibility and ability to take advantage of the growing power of networking.

This underlines the imperative of designing a fleet using cost as a strategy. Key to this is designing a fleet made up of lower unit cost systems. This delivers a fleet architecture that can scale better to increases or decreases in the resources for shipbuilding as well as provide the ability to adapt much more rapidly to changes in the security environment.

A new set of rules has emerged, driven by advances in technology and experiences in organizational behavior, which forms a basis for designing a powerful, adaptable fleet made up of lower unit cost elements. These fundamentals are interrelated and include:

- **Capabilities of a fleet are decoupled from platforms:** Modularity and networking permit a new flexibility in designing a fleet architecture that decouples the capabilities of the fleet from the sum of the capabilities of individual platforms.

- **Power and survivability of a fleet have been decoupled from size:** Advances in precision and high energy density warheads mean a small ship with high payload fraction can deliver the same military effects formerly reserved for much larger platforms. Small ships can also be designed with greater speed, maneuverability, and a smaller signature, enabling them to elude detection, tracking, and strike.

- **Information has been substituted for mass:** The rapid growth in the capacity to process and transmit information means that forces can disperse, therefore increasing survivability, while still massing firepower where needed.

- **Sensor proximity and persistence will drive the utility of weapons reach:** Aircraft or ships can strike targets from hundreds or thousands of miles away. Key to success on the future battlefield will be dispersed sensor networks that can cover a wide area.

- **Mass customization delivers greater value than mass production:** Mass production of highly integrated platforms limits options. On the other hand, mass customization that

begins with a basic model, but allows system modules and other features to be changed as advances in design occur, preserves options.

- **Networked components outperform integrated systems:** Networking allows multiple platforms to coordinate and combine firepower and sensor capacity to deliver concentrated and precise effect.

The foregoing suggests a ***new set of metrics*** for designing a future fleet architecture. Primary among these is the power of creating and preserving options both in designing and operating the fleet. In designing the future fleet architecture, the Navy could extend competition further to include building, testing, and experimentation with more prototype designs. Likewise, expanded experimentation in the operational fleet would provide the commander with an expanded set of operational choices that would complicate the enemy's problems in responding.

High transaction rates in fleet development allow us to adjust to the future as rapidly, or more rapidly, than an adversary within the dynamic and complex battlespace of the future. Transaction rates grow as the number of interactions with the competition and the environment grows. The quantity and quality of those interactions over time generates information about the battlespace that, when distributed and acted upon, drives up learning success.

High learning rates are essential for the Navy to maintain its effectiveness in an age where rapid change is a key to competitive advantage. The key for the Navy is to create experiences at high rates, to include continuing to explore options that were developed and initially rejected. The more the Navy experiments with new ideas, the higher the rate of learning and the more quickly the lessons can find their way into the fleet.

Taken together, the imperatives of a changing, dynamic strategic environment described in **Chapter 2**, the lack of adequate resources to build the programmed fleet architecture, the high leverage opportunities presented by advances in technology, and new rules and metrics provide an alternative framework for future fleet platform architecture design.

Some specific examples of what an alternative future fleet architecture might look like are detailed in **Chapter 6**. These three alternative architecture examples incorporate smaller, lower unit cost ships. The ships can carry different modules appropriate to the mission. Combat aviation is carried on an increased number of small carriers. Lower cost Air Independent Propulsion (AIP) diesel submarines are substituted for some nuclear powered attack submarines (SSNs). Finally, generous use is made of unmanned vehicles to perform high-risk surveillance, ASW, and mine warfare operations.

The result is an ***alternative fleet platform architecture*** with many more ships that can form a more robust network, disperse over a broad area for survivability, and scale up or down as resource availability permits. A key advantage is that such an architecture presents the enemy with a much more complex problem—both in his force planning and operational planning. There are many more entities for him to keep track of; they can move more quickly; and configuration, capabilities, and intent are uncertain.

A comparison of the fleet's capabilities and survivability under fire is shown in **Chapter 6** as well. The analysis shows the alternative fleet to perform better than the programmed fleet architecture. Finally the alternative has been deliberately positioned to capture trends in technology. As key technologies, especially information technologies, advance, the capabilities resident in the alternative architectures can grow apace.

2. Strategic Context

A New, Different, and Uncertain Era

Setting requirements for naval capabilities and investment must take into account both that we are transiting from one global security era, the Cold War and immediate post-Cold War, to a new era and that the new era is more dynamic and less predictable than the old. Reference is made to the Cold War because the current fleet and its design logic represent the overhang or "fossil remains" of that earlier era. This distinction between era transition and era instability is important. The shift from relatively clear requirements to different, but also fluid and less clear requirements, implies a change not only in what future fleet architecture will be needed by the U.S. Navy, but also in how it should be built and kept relevant.

From what we have seen of it so far, the new era is sharply different from the old in terms of the Navy's role in global security:

- **Global Security in the Cold War Era:** The Cold War era was marked by the potential for all-out war at sea against a global power unwilling to yield control of the oceans to the U.S. Navy. This pivotal planning assumption combined Alfred Thayer Mahan's concept of sea power with a recognition that the U.S. Navy—particularly its aircraft carrier battle groups and submarine fleets—required capabilities to survive and prevail against an enemy fleet with formidable surface, submarine, and air capabilities. Accordingly, the missions for which it was designed were mainly anti-surface, anti-submarine, and anti-air warfare, as well as nuclear deterrence. In the East-West struggle, the world's oceans were of strategic importance, and the Navy was America's strategic answer on the high seas.

- **Global Security in the New Era:** The new era, so far, involves frequent contingencies of a wide variety across a wide geographic arc against an assortment of adversaries, none of which can compare to U.S. naval or overall military strength. The spectrum ranges from major combat to counter-terrorist operations to semi-permissive and permissive stability operations, e.g., peace-making, humanitarian relief, and nation-building. The need to engage in land-expeditionary contingencies is the result of the global security interests, responsibilities, and challenges the United States has been required to meet. In addition, although the U.S. homeland is less exposed to strategic attack by a rival peer, it is more exposed to desperate and daring acts of terrorists and rogues, the best defense against which is to find and eliminate the terrorists abroad. In such land-expeditionary interventions, the Navy can play a vital enabling role in the success of the joint force, into which it is increasingly integrated. Thus, while currently unchallenged on the high seas, the Navy must operate in littoral waters that can be made unsafe by asymmetric weapons and tactics of lesser powers. In sum, having been designed and built mainly as a high-seas strategic instrument for an earlier era, the Navy has become an active instrument of U.S. intervention and self-defense policies. We have designed and built one Navy and are operating another.

If we could be sure that the future will stabilize more or less along these latter lines, we could concern ourselves only with fleet requirements for era transition, i.e., for joint land-expeditionary operations against asymmetric adversaries. We would spell out as exactly as possible the characteristics of the new era, adjust requirements accordingly, and invest to meet those requirements. Once the fleet was refashioned according to this model of the new equilibrium, reversion to the old paradigm of incremental modernization would work, at least until the onset of another new era.

However, the technological and geopolitical dynamism unleashed by the information revolution, the end of Soviet communism, globalization, and "9/11" are likely to be with us for some time. This militates against reliance on experience-based forecasts of how the new era will unfold. Thus, for all the recent emphasis on preparing for a long-term "global war on terrorism," using the intervention in Afghanistan and counter-insurgency operations in Iraq as the principal basis for planning could prove to be a grave miscalculation.

Generalizations about the new security landscape based on the first Gulf War were largely demolished by the Balkan wars of the 1990s and the long-term peacekeeping and peace enforcement missions that followed, which required the stationing of U.S. and multinational ground forces in Bosnia and Kosovo. Similarly, projections for the new era based on these recent Balkan wars were shattered by 9/11 and the lightning U.S. attacks on the Taliban and Al Qaeda in Afghanistan that followed in 2001-2002. The successful U.S.-led invasion of Iraq in 2003 and the rapid overthrow of Saddam Hussein's Baathist regime have been followed by an extended period of combat, beginning in May 2003 and continuing to the present, between U.S. forces and our multinational partners and a potent combination of Iraqi insurgents and foreign terrorists. These new threats to the stability of Iraq and the nature of this insurgency, located mainly in the cities and towns of the Sunni Triangle, led to a growing requirement for U.S. and multinational ground forces to conduct urban operations against enemy cells. The experiences of our forces in Fallujah and other predominantly Sunni towns would suggest still different generalizations, no less likely to be invalidated by events to come. In sum, treating the last decade as prologue to the decades ahead is fraught with peril in setting requirements for military capabilities—even moreso for the Navy than for the other Services, given the capital intensity and life expectancy of a fleet.

Nonetheless, today's defense planning tends to take as a given that the swath of lands from the Eastern Mediterranean through Southwest, South and Southeast Asia to East Asia will be the theater of such interventions, with some additional possibility of minor intervention operations in trouble spots of sub-Saharan Africa or the Caribbean. The perceived likelihood of expeditionary operations against outlaw states and terrorists, combined with the difficulty of predicting where and when they will occur, has given rise to the concept of basing land-intervention forces at sea, supported by ship-based attack and extended-defense capabilities. Accordingly, the Navy is wrestling with the challenge of transforming an essentially high-seas fleet into one that delivers what it calls Sea Basing, Sea Strike and Sea Shield. On the assumption that the future is more or less as just described, the Navy's construct is a useful one for planning naval capabilities. Whether that construct has led to the optimum fleet architecture and naval investment program for such a future is a different matter and a central issue of this report.

Because of era instability, however, it would be a mistake to count on this assumption for a matter as weighty as preparing the U.S. Navy for the future. Even if the coming decade resembles the last one, it would be foolhardy to forecast that the challenges of 2020 or 2030 come only from rogue states, global terrorism, and humanitarian interventions. The future Navy must be far more versatile than what is implied by either the old era or the period since then.

For example, take the impact of the current conflict in Iraq. In the best case, it could make interventions in Southwest Asia and elsewhere less necessary by setting in motion positive regional political trends, deterring other hostile states, inducing regime change and isolating terrorists. In a less good case, it could set the stage for similar interventions against intransigent dictators seeking weapons of mass destruction and harboring terrorists. In a third case, international and domestic backlash against the Iraq war, if it does not go well, could militate against overseas military interventions generally—a phenomenon known to have happened before in modern American history. The post-Cold-War era of U.S. interventionism could end.

Or, consider China. If Taiwan's status is resolved peacefully or at least managed skillfully, the logic of cooperation between China and the United States could prevail over the logic of rivalry. Or vice versa. The Chinese have intensified investment in modern, advanced-propulsion submarines, ballistic missiles, and extended range sensors. Depending on Sino-American relations and what becomes of Taiwan, these investments could prove benign or become menacing to the freedom of the U.S. Navy to operate in the Western Pacific. In one case, China might expand investment in area-denial and its own power-projection capabilities, seeking to deny the United States control of and extend Chinese influence across East Asian waters. In another, China might conclude that national success depends on avoiding confrontation and competition with the United States.

In a sense, experience since 1989 has been so varied as to argue against forecasting a future based on that experience. Flat predictions of decades more of intervention against rogue states and terrorist cells seem as shaky as predictions of Sino-American confrontation. At the same time, failing to predict at all would leave naval investment adrift against currents of bureaucratic inertia, special-interest politics, and technological randomness. Moreover, failing to develop adequate capabilities to intervene abroad would foreclose U.S. options, and failing to prepare for a confrontation with China could invite one. So we must make a concerted attempt to peer into the future, or future*s*, as the basis for conceiving the capabilities of the future fleet and shaping an investment strategy with those capabilities in mind.

Planning for the Unpredictable

There are a variety of respectable methods to plan for an unpredictable future, e.g.:

- Being very general, given that generalities are less likely to be mistaken;

- Identifying a "space" of many futures, giving attention to the key determinants rather than to any particular (point) combination of them;

- Developing a portfolio of specific scenarios—the more the better;

- Bracketing the range of plausible futures; and

- Proceeding incrementally and adaptively toward general goals while collecting information and observing indicators along the way that settle at least some uncertainty and suggest what paths to take toward those goals.

For our purposes of generating requirements for naval capabilities, the last two methods, in combination, seem especially useful. It is possible to bracket the future by imagining two futures different enough to pose very different demands, yet both plausible. Alternative fleet architectures can then be drawn up and tested against the demands of each future, and if practical a richer set of possibilities. In this way, the alternatives can be judged both by their ***suitability*** for one future and by their ***robustness*** across the range of futures lying between the brackets, e.g., a hybrid of the two futures. At the same time, the passage of time and development of world affairs will furnish information that may clarify the future's general course and character. This may, in turn, provide a basis for modifying the fleet architecture. In this light, the architecture must be not only robust across a range of futures but also flexible by design.

The two futures we find most suitable for planning are called ***Intervention*** and ***Strategic Advantage***. They signify quite different ways of thinking about the utility of maritime power to the nation. Of course, the future could prove to be a combination of the two, in which case the suitability of the U.S. Navy for both—i.e., its robustness—would be critical.

- **Intervention Future:** The Intervention future is more or less an extrapolation of the U.S. policy trend-line for the last dozen years, intervening in Kuwait, Somalia, Haiti, Bosnia, Kosovo, Afghanistan, Iraq. The premise is that U.S. interests, values and perhaps homeland security merit continued expeditionary military operations as a policy instrument of U.S. involvement in the world, be it unilateral or multilateral. Military intervention may be against either states or non-state actors, e.g., terrorist and insurgents. While familiar, the demands on U.S. naval forces of this future are what one would consider non-traditional—asymmetric, irregular, elusive, and more littoral than ocean-going.

- **Strategic Advantage Future:** Strategic Advantage assumes that military intervention on land comes to look inefficacious or non-essential for the United States, perhaps because of lack of international support, increased costs, reassessment of interests, or complete success against current enemies. So the United States becomes less predisposed to intervene around the world. But it does consider it imperative to maintain a dominant strategic position, of which naval supremacy is a prominent dimension. The United States may do this to dissuade a strategic challenger, to confront one if dissuasion fails, or to safeguard the world's common and increasingly vital maritime trade lanes.

Let us look at each future in more detail, and then consider the implications for fleet requirements and investment strategy.

Intervention

Emphasis on land-expeditionary intervention would represent an extension of current policy. In this future, as now, the U.S. Navy is treated as a readily usable policy instrument for enabling the United States to project and insert joint military power, either to back up diplomacy or to act if diplomacy fails. For an interventionist America, maritime power provides credible options to display resolve, exert pressure or deliver force promptly, flexibly, and without need of land basing—wherever, whenever, and against whatever adversary U.S. interests, values, or responsibilities might require.

The utility of this policy instrument is predicated on the U.S. perception that international and national security depend on the believable will and unmatched ability to intervene abroad, on land, leading coalitions whenever possible. While naval power may be used on its own (e.g., to intercept terrorists on the sea or to deliver strikes against land targets), the more demanding the contingency, the more likely it is that it will be used in conjunction with land forces and land-based air forces. Networking will permit increasingly integrated joint operations, with advantages in lethality, precision, maneuverability, and survivability.

Although the basic theme in the Intervention future is consistent with U.S. policies since the end of the Cold War, the demands will surely change. Adversaries' adoption of asymmetric tactics and weapons, combined with their acquisition of more capable weapons, could pose new risks to expeditionary forces. Land-based missiles, mines, small coastal assault boats, diesel submarines, and weapons of mass destruction could make littoral waters more dangerous, which in turn could make naval support for land interventions more difficult. Those being intervened against may try to strike high-value U.S. targets, including American soil, in response to U.S. intervention, or the United States may intervene to preempt such dangers. The rise of sub-national adversaries will present new operational challenges, e.g., finding and eliminating terrorists, fighting insurgents hidden in the crowds and alleys of cities, and interdicting flows of fighters and arms.

Because of likely increases in adversaries' capabilities in the Intervention future, the U.S. Navy would have to be more capable—lethal, survivable, sustainable, flexible, versatile, inter-operable—of supporting distant joint military interventions than it is now. Building on the Navy-Marine relationship, the fleet could be expected increasingly to transport land forces to the theater and onto the battlefield, and back them up with logistics, strike, and defensive capabilities (the Navy's Sea Basing, Sea Strike, and Sea Shield nomenclature). Therefore, even if the future does not change radically from the present, this is no reason to argue that the U.S. fleet does not need to change. While the Navy has been shifting from a focus on the conduct of "war-at-sea" to "strike," this addresses only a part of the capabilities it will need to support intervention and joint expeditionary operations.

Strategic Advantage

In this alternative future, maritime power is both a contingent military instrument and an unshakeable strategic fact—usable in the event of challenges or incidents, but useful as a deterrent, an expression of power, and a source of global confidence even if not used for actual

combat operations. Regardless of whether a major threat exists, U.S. geographic remoteness and dependence on global markets and production make naval power as strategic for the United States in the 21st century as it was in the 19th for the British Empire, which faced no enduring enemy. With its global fleet, the United States could set favorable systemic conditions – its standing unrivalled, its global access unimpaired, world trade and energy supply routes open, and mankind's common waters secure. While less inclined to intervene with ground troops, the United States would retain worldwide influence from the sea. Whether viewed in classical geo-political terms or in terms of an increasingly integrated world economy, a commanding maritime-based strategic position for the United States—also being the economic and technological leader—would guarantee U.S. and global security without requiring "routine" land interventions.

More specifically, maritime supremacy could be used by the United States to dissuade military adventurism and power projection by those able and tempted to mount such challenges. With a dominant navy, the United States could set conditions not only for its own strategic security and global interests but also to safeguard the integrated world economy. Strategic Advantage would ensure that the United States has supremacy in any competition or conflict in which maritime power can be brought to bear. This could include intervention, but not as its main purpose.

Strategic challenges could include regional hegemonic aggression, hostile power projection, threats to U.S. territory, and threats to vital resources and trade routes. Even if a peer challenger does not rise up, a variety of unfriendly actors could use the oceans to transport dangerous materials and people, and disrupt world trade. These actors include sophisticated, well-resourced rogue states and non-state actors, as in the Intervention future.

Of course, China would be of special concern, given its economic scale and dynamism, its technological potential, and its regional ambitions and insecurities. Even if a military factor only in the East Asian region, the vital importance of that region to the world and the United States give it strategic significance. Curbing Chinese attempts to use military power coercively without relying on threats to use land forces or to strike against China proper is largely a maritime strategic challenge for the United States. The model of U.S. joint land-expeditionary warfare that has been formed by the interventions of the past dozen or so years does not fit most scenarios of Sino-American crisis. The U.S. Navy may be the most important military instrument for convincing China to pursue its regional and global interests in ways that do not confront U.S. power or contest the interests and international norms that that power serves.

Thus, the basic premise of this future is that the land interventions of the period from 1990 to 2004 are not necessarily indicative of the future, at least not beyond the next few years. Instead, new conditions—an emergent China, various threats to vital trade routes of an integrated world economy, the declining efficacy of ground-force intervention—point to more of a grand maritime strategy for the United States. In this future, although the Navy would maintain capabilities to support joint expeditionary operations on land, it would have to prepare to prevail decisively in hostilities on the world's ocean commons, whether or not the other Services are involved. Instead of being mainly a supporting service, it would often operate autonomously or at least have the lead.

Implications for Requirements

With this strategic context in mind, specific capabilities that the fleet would require in the future were developed. In the spring of 2004, two decision support workshops were conducted at the Naval War College. Workshop participants were charged with exploring how changing global conditions can inform the Navy about the capabilities it must field to meet future challenges. Specifically, their primary objective was to develop a prioritized list of capabilities for the future fleet architecture design. These workshops are described and the results presented in **Appendix A**. Requirements that grew out of these workshops provided a foundation for the alternative fleet architectures presented in **Chapter 6**.

The exercise of setting requirements for one or the other of these two futures does not imply that the United States need bet all its chips (or ships) on one and dismiss the other. Certain capabilities will be essential in both futures. More generally, it is instructive to review the similarities and differences in the capabilities implied by these futures.

Both the Intervention and Strategic Advantage demand certain capabilities:

- **Persistent intelligence, surveillance, and reconnaissance (ISR):** As long as the U.S. Navy is expected to operate worldwide, as is the case in both alternatives, the ability to scan and stare where necessary is important. While the Navy can depend on other services for ISR, it should also address it own needs and contribute to meeting those of other services. Thus, naval ISR should be an integral part of Department of Defense (DoD) national ISR.

  Additionally, the ability to collect and process large amounts of information about ships bound for U.S. ports is likely to be a key future role for the Navy. Working with civilian authorities, the Navy could well be called upon to help track and, as needed, challenge ships on their way to the United States.

- **Access to networks for abundant information and easy command, control, and communications (C3):** The benefits of extensive, open, broadband data networks are of value in any case, including as a key to exploiting ISR. Because of mobility and flexibility of sea-based C3, the U.S. Navy can contribute to joint C3 while satisfying its own needs. It must also use joint networks for access to information gleaned by the airborne and spaced-based sensors of the Air Force and national ISR assets.

- **Theater ballistic and cruise missile defense:** Inability to protect against theater missile threats could hamper joint-force interventions, littoral operations and sea control, inviting adversaries to invest in precisely these weapons to hold the U.S. Navy and other forces at bay. Because of its flexibility, sea-based missile defense can contribute importantly no matter what the future holds.

- **Precision strike:** Whether against land targets in support of joint forces or against sea-based targets, this capability improves the lethality, economy, and discrimination of offensive operations and helps neutralize threats. In view of recent munitions

improvement, the chief aim is no longer greater precision, per se, but making it operationally decisive:

  - **Prompt** precision strike is important against critical fleeting targets, e.g., missile launchers and terrorist leaders, which could figure importantly in either future; it requires better ISR-C3-weapon networking, above all.
  - **Discriminating** precision strike, also depending on enhanced ISR-C3-weapon networking, will be important for delivering effects in urban and other sensitive areas.
  - **Large-volume** precision strike may be crucial against larger opponents and requires continued reduction in weapon size and unit costs.

- **Versatile strike:** Both futures could require operations almost anywhere and against a wide range of adversaries from major land power to pockets of terrorists to high-seas piracy to hostile power projection. This places a premium on scaleable and versatile strike capabilities.

In sum, there seems to be a core of naval capabilities of value in either future (and in other futures as well). It includes sensors and networking to enhance awareness and collaboration, defense against a range of missiles threats, and being able to strike with precision, speed, volume, and versatility. It is reasonable to conclude that these are general capabilities the U.S. Navy will need whatever the future holds and whatever fleet architecture is indicated.

Preparations for the Intervention future would also stress the following capabilities:

- **Joint operating information-access and collaboration:** Because joint operations are a necessity for land expeditions but not (or less so) for sea control, the networks needed to conduct them are an especially high priority in this future. Ship-based joint C3 is attractive because of the mobility and flexibility it affords.

- **Rapid joint-force mobility:** While desirable in any future, the Intervention case poses the greater demands for strategic and theater mobility. The need for naval capacity to move and support large, possibly heavy ground forces is increasingly apparent, as it becomes harder to pin-point where forces will be needed. Speed and the ability to maintain distant presence in peacetime, crisis, combat, and post-combat conditions may be critical.

- **Access to and control of littoral waters:** While desirable in both cases, littoral control is indispensable in a future characterized by joint expeditionary warfare. Shore-based missiles, submarines, mines, swarming gunboats, and suicide terrorists present an increasingly dangerous environment for interventions.

- **Joint-force logistics:** Hand in hand with rapid joint-force deployment is the capacity to maintain stocks afloat, given the uncertainty of location of future contingencies. Moreover, the ability to transfer materials, marry them with troops, and support forces within a theater could be a major naval responsibility in this future.

- **Forcible entry:** Maritime capabilities may be critical not only for traditional amphibious operations but for fighting from off-shore to establish, exploit and expand land lodgments. In this future, sea-based air-strike capabilities must include close support for land operations.

- **Insertion, support, and extraction of special operations forces (SOF):** Clandestine operations can require extensive sea-based transport, support, ISR, and C3.

In sum, in addition to the core capabilities, the Intervention future places a premium on the capabilities to respond rapidly and to insert and sustain sizeable or specialized joint forces ashore, to contribute to joint strike operations, and to provide joint C3, even as near-land waters become increasingly infested with state and perhaps non-state threats.

A future in which the U.S. Navy is required to stress Strategic Advantage would place a premium on the following capabilities:

- **Surface warfare:** Capabilities to destroy surface combatants while avoiding destruction could become important again for the U.S. Navy. Although the high-volume, precision, versatile strike capabilities required in any future may suffice, more specific ones (e.g., fleet missiles and fleet missile-defense) could be needed.

- **Counter-power projection:** To deny any challenger the ability to project power, surface-warfare, strike and missile-defense capabilities would be relevant, as would the ability to move sizeable naval forces over strategic distances with great speed to thwart enemy force projection.

- **Undersea warfare:** While littoral anti-submarine warfare (ASW) capabilities may be required in the Intervention future, Strategic Advantage would require both that and possibly strategic ASW, capable of expansive coverage and detection of sophisticated (quiet) submarines that could threaten the fleet or even the homeland.

- **Strategic nuclear deterrence:** An invulnerable and potent sea-based nuclear force would reinforce the objectives of strategic superiority and invincibility implied by a Strategic Advantage future.

- **National missile defense:** While relevant to the Intervention future (if lesser adversaries counter the threat of intervention with long-range missiles), national missile defense is indispensable in a future in which the United States seeks an unassailable Strategic Advantage. Because of its mobility and flexibility, sea-based missile defense—sensors as well as interceptors—can contribute significantly to national missile defense.

In sum, in addition to the core naval capabilities, the Strategic Advantage future demands forces that can prevail against the naval surface and sub-surface forces of a large power, can control both open and narrow seas vital to trade, and are survivable against long-range attacks from land.

Planning for Both Futures—Not One or the Other

It would be a mistake to plan for one future—even one like the present or either of the two futures we have postulated—to the exclusion of others. Therefore, a critical question for the future fleet, and for the analysis, planning, and investment to produce one, is how to prepare for both of these two different futures (while keeping an eye on other possibilities). Here are some basic alternatives:

- **Plan for one future; hedge for the other:** Future fleet capabilities, and thus investments to create them, would be deliberately biased toward one or the other future. However, those capabilities and investments indicated must be tested against the requirements for the other future. As noted, some core capabilities will be of value in both. Otherwise, calculated risks may have to be taken where requirements of the other future are unmet—risks that can be mitigated by some additional capabilities and investments that provide a hedge. To illustrate, if the Intervention future is favored, surface combatants (e.g., destroyers and cruisers) and nuclear-powered attack submarines may be de-emphasized quantitatively but kept current qualitatively in order to permit a form of "break-out". Testing and hedging for the other future should take into account warning time—from a few months to many years—and signals in the event that initial expectations turn out to be mistaken. With warning time, it is easier to create options through R&D and experimentation while deferring procurement until conditions are clearer.

- **Prepare for both futures with "two navies":** Depending on national priorities and available resources, it may be that the U.S. Navy should be prepared for both futures. Although there are important common core capabilities, the requirements of the two futures described here could be sufficiently different to warrant separate capabilities for each. Thus, for example, strong strategic forces ballistic missile submarines, ASW, and national missile defense would be justified for Strategic Advantage while the ability to transport and support joint expeditionary forces (Sea Basing) would be justified if Intervention remains a national priority. Not only would the two navies be different, but so would their respective support, technical, and industrial bases. Obviously, the Navy and the nation would face a trade-off between cost and risk, which of course could be biased toward one or the other future and shifted as events unfold. If determined to keep risk low in all naval missions, the costs of two navies could be far greater than current defense budget projections and fiscal conditions would permit.

- **Plan for both futures with common capabilities:** In order to economize on cost while addressing both futures, capabilities required especially for one but not the other could be kept more modest, in scale or sophistication, than in the "two-navies" option. Because of this, setting priorities and assessing risk would be critical, as would vigilance for signals of which direction to adapt. As in the other approaches, core capabilities required in both futures would receive priority attention in fleet architecture and investment. It would be a mistake to assume that the different requirements of the two futures indicated above (apart from the core) cannot be met well enough by the same architecture. All else being

equal, any architecture that tests well against both alternative futures should be favored over any that tests well against only one.

What makes fleet requirements setting and investment planning especially challenging is the fact that fleets have a way of outlasting eras, especially eras that end abruptly (e.g., in 1914, 1945, and 1989). Historically, fleets have tended to fall at least somewhat behind the times and thus have been used for purposes other than intended. As noted, most of today's U.S. Navy platforms—nuclear powered aircraft carriers (CVNs), surface escorts, nuclear-powered ballistic missile submarines (SSBNs), nuclear powered attack submarines (SSNs), amphibious ships, and related auxiliaries—were conceived to prevail in a general war against the Soviet Union. Although the period since the end of the Cold War has been dominated by joint expeditionary operations, it has been carried out by a fleet largely designed for a different purpose. The U.S. Navy is not optimized for an era of Intervention, though modernization has nudged it incrementally in that direction.

At present, this lag has implications for setting requirements and planning investments for the future. Paradoxically, although the Intervention future resembles the current security environment, preparing for it could require more significant changes in requirements than would preparing for the Strategic Advantage future. This is because today's fleet embodies types of capabilities reflecting the Soviet naval threat (and before that the Japanese and German naval threats) that are more relevant to a future Chinese threat than to maritime support for joint land-expeditionary warfare.

Whatever the future, the U.S. Navy must be based on network principles. Networking provides both extraordinary advantages at any moment but also a way to cope with uncertainty and change. The virtue of networks is that they embody more capability, or value, than the separate components do. Data networking has shifted functionality from individual machines (e.g., platforms, weapons, and other systems) into the architecture from which they get information and through which they work together. At the same time, networks are more easily reconfigured, adapted, and continuously improved than are machines. In time, any networks of machines—including even naval platforms—can exploit these trends, as the use of the global positioning system (GPS) to guide weapons (e.g., joint direct attack munition [JDAM]) already shows.

Even the rigidity of fleets—taking longer to be altered than it does for the world and requirements to change—does not have to be an immutable law. Just as networking can provide flexibility and adaptability to changing requirements, so can increasing the modularity of naval capabilities. Facing a fluid, complex and unpredictable security environment—"era instability"—argues for relying on common interfaces on a variety of platforms that can be configured to address a range of futures bracketed by the two that we analyze in this study. This provides the ability to adjust the fleet as the future evolves. In sum, the architectural principles of networking and modularity go a long way to resolve the dilemma of planning for one future to the exclusion of the other or else maintaining two navies.

Conclusion

At this juncture, it would be difficult and perhaps risky to bet on either of the two futures indicated. Both have antecedents in today's world. Similarly, the Intervention future calls for operations against asymmetric state and non-state adversaries, including terrorists and others that favor irregular war. But China's clear interest in growing naval and anti-naval capabilities to hold the U.S. fleet at risk suggests that treating the Strategic Advantage future as unlikely or of secondary importance could be a mistake. Therefore, we give the two futures equal weight. This argues against a fleet designed for one future, but hedged for the other.

The choice between the "two-navy" approach and a single architecture to meet the needs of both futures boils down to how much overlap there is in requirements. We have already postulated that there are significant core capabilities required in both—and almost any other plausible—futures. Beyond that, the critical question is whether an architecture that measures well against Intervention Requirements will measure well also against Strategic Advantage requirements.

A fleet architecture based on network principles appears promising for different futures for different reasons. In particular, a networked fleet with large numbers of ships, many of them small, maneuverable, and fast, can operate in a dispersed yet coherent fashion. In the Intervention future, such a fleet would have the advantages of being able to cover a wide expanse of water, locate and track enemy units, and bring force to bear in many places at once. In the Strategic Advantage future, such a fleet would enjoy greater survivability against naval and land-based threats. In both cases, "numbers matter," though for different reasons. This suggests the possibility of designing an alternative future fleet platform architecture that would be advantageous in either future, while actual requirements could be met by modular systems, such as missile defense, command and control, ASW, or land attack.

The analysis that follows in this study examines the possibility that an alternative fleet platform architecture based on networking, modularity, and adaptability could meet the requirements of both futures without requiring, in effect, two separate navies.

3. Budgetary Challenges

Overview

Since 2002, the U.S. Navy has had on the table a long-term plan to modernize and expand its fleet from the 286 ships in the fleet today to 375 ships in the future. The plan's feasibility is highly uncertain. A change appears inevitable. In its FY2005 shipbuilding report to Congress, the Navy presented possible alternative plans, one targeting a fleet of 260 ships and one targeting a fleet of 325 ships. The key issue facing the Department of Defense (DoD) and the Navy is that the available budgetary resources are unlikely to be adequate to fund the existing plan, not only during the Future Years Defense Program (FYDP) period of 2006-2011, but also beyond Fiscal Year (FY) 2022. If future Navy budgets are expected to be inadequate to bring the programmed architecture to life, alternative fleet platform architectures will have to be considered.

The purpose of this chapter is not to predict the future or draw a fixed blueprint for the Navy. Instead, its purpose is analytical: to illuminate the key assumptions, constraints, and implications so that impending choices can be better understood. This chapter begins by describing the Navy's shipbuilding plans, including those for the long-term. It then analyzes five key assumptions upon which these plans are based. All five appear to be overly optimistic.

- **DoD Budget Growth:** DoD's budget top-line continues to experience the real growth projected through 2011 and beyond, and within that top-line, DoD's procurement budgets grow strongly.
- **Supplemental Funding for DoD:** Supplemental spending bills will largely fund war operations in Iraq and Afghanistan so that money does not have to be pulled out of the core DoD budget for this purpose.
- **Navy Budget Share:** The Navy continues to receive the share of DoD's overall budget (and procurement budget) that is envisioned by its shipbuilding plan.
- **Navy O&M:** The Navy succeeds in restraining O&M cost growth through BRAC and other measures.
- **Navy Shipbuilding Costs:** The Navy successfully controls the over-budget construction costs of its new ships despite sharp cutbacks in R&D.

Our analysis of the five key assumptions concludes that the affordability of the Navy's shipbuilding plan is far from certain. The Navy will be able to procure all of the ships in its current plan only if favorable trends unfold in all five areas. If unfavorable trends—a combination of smaller Navy procurement budgets and higher expenses for new ships—dominate, the Navy will not be able to buy the 207 new ships now included in its shipbuilding program during 2006-2022, or to enlarge its fleet to 375 ships by 2022. Significantly, the President's FY2006 Budget Submission cuts Navy and Marine Corps modernization programs by $13.7 billion during the FYDP period of 2006-2011. This is a portent of the potential problems for the Navy's shipbuilding plans in the years ahead.

A problem facing the Navy (as well as the other Services) is that procurement budgets are neither fixed nor easily controlled. They are "elastic" and subject to outside pressures aside from requirements. When defense budgets rise, and other expenditures (notably personnel and operations & maintenance [O&M]) are held in check, procurement budgets can grow significantly. But when defense budgets tighten, and other expenditures are rising as they are today, procurement budgets suffer. Likewise, future construction costs for new ships are not fixed. Instead, they can rise above original estimates for a variety of reasons: e.g., new capabilities or higher labor costs. The combination of constraint on procurement budgets and rising construction costs can compel reduction in long-term shipbuilding plans irrespective of whether a legitimate requirement exists for these plans.

The Navy's Future Force Architecture and Shipbuilding Plan: Ambitious Goals

DoD is seeking to move from "threat-based planning" as practiced during the Cold War, to "capability-based planning," which calls for a flexible military posture able to meet a wide spectrum of future challenges. For the Navy, this means ensuring that the fleet has the capabilities to perform two broad classes of critical missions in the future:

- Conduct expeditionary interventionist operations in the near-to-mid term; and
- Maintain its strategic advantage in the ocean commons over adversaries that might try to deny it access to important regions.

New Navy Concepts and Plans. The ships in the Navy inventory as of the beginning of 2005, shown in **Table 3-1**, were designed for the Cold War and reflect its operational requirements. This fleet is far smaller than the posture of 550-600 ships sought for the Cold War in the 1980s, and is smaller than the 400+ ships endorsed by the first Bush Administration in the early 1990s. In 1993, the Clinton Administration, in its Bottom Up Review (BUR) study, endorsed a Navy of 346 ships; its 1997 QDR reduced the number to 310 ships—the last DoD-authorized target.

Carriers	12*
Amphibious Assault Ships	37
Cruisers	23
Destroyers and Frigates	69
Attack Submarines	54
Other Ships	91**
Total	286

*Does not reflect the possible early retirement of *USS John F. Kennedy*

**Includes ballistic missile submarines, combat logistics ships, and command and support ships

Table 3-1. Current Navy "Battle Force" Ships—2005

To strengthen its capacity to support the U.S. defense strategy, the Navy is proposing to modernize and to expand its existing fleet to 375 warships in the next 15-20 years. This goal is to be achieved by accelerating naval shipbuilding from 7-9 ships per year to a peak of 14-15 ships in the out years.

The Navy judges that in the future, it will need to deploy 12 Carrier Strike Groups (CSGs), 12 Expeditionary Strike Groups (ESGs), 9 Strike/Missile Defense Surface Action Groups (SSGs), 4 Special Operations/Strike Units composed of converted SSGN submarines (SSGN/SOF Strike Units), plus Maritime Prepositioning Groups (MPGs) and logistic support assets. The requirement to populate these operational units with sufficient warships and support ships is the main analytical rationale for the Navy's 375 ships target to be complete by the early 2020s. While the exact composition of the future force is flexible, **Table 3-2** illustrates how it might take shape.

Carriers	12*
Amphibious Assault Ships	37
Cruisers, Destroyers, Frigates	104
Littoral Combat Ships (LCS)	56
Attack Submarines (SSN/SSGN)	59
Minewarfare and Other Ships	107
Total	375

*Does not reflect the possible early retirement of *USS John F. Kennedy*

Table 3-2. Future Navy Posture of 375 Battle Force Ships—Illustrative

Compared to today, the number of carriers and amphibious assault ships stays largely constant. The number of carriers is dictated by the current requirement to keep 2-3 CSGs constantly deployed abroad and to meet wartime surge requirements. The amphibious assault force is sized to carry the initial echelons of 2.5 Marine Expeditionary Brigades (MEBs) and to keep 2-3 ESGs continuously deployed. The size of the surface combatant force is largely dictated by the requirement to escort CSGs and ESGs and to deploy nine SSGs. The biggest change is the projected acquisition of 56 Littoral Combat Ships (LCS), which will provide a capacity for littoral operations. The future size of the attack submarine force is an uncertain variable: although current plans call for 55 nuclear powered attack submarines (SSNs) and 4 SSGNs, some studies call for a buildup to 76 submarines and others envision a drawdown to 37 submarines. Other elements of the shipbuilding program being held constant, a drawdown to 37 submarines would reduce the overall force to 357 ships, and an increase to 76 submarines would enlarge it to 396 ships.

The Navy's Shipbuilding Plan: Slow, Steady Expansion. To grow to 375 ships, the Navy plans a slow-but-steady expansion that would unfold over the next twenty years or so. Provided below in **Table 3-3** is a projection of how this buildup is envisioned to take place according to the latest official Department of the Navy program. Through 2006, the Navy posture is forecasted to shrink slightly as older ships are retired early (despite having up to 5 to 10 years of

remaining service life) to save on operating costs to free up money for acquisition. The posture is projected to reach and pass the currently authorized level of 310 ships by 2011. The expansion to 375 ships is projected to be one-half complete by 2017-2018 and complete by 2022, seventeen years from now. Afterward, the fleet is projected to remain roughly constant in size (369-378 ships) through 2033.

Year	Force Size	Year	Force Size
2006	291	2018	346
2008	301	2020	365
2010	308	2022	375
2012	317	2024	378
2014	322	2026	375
2016	331	2028	372

Table 3-3. Future Navy Posture—Gradual Buildup

A main implication of this gradual buildup is that the rationale for a 375-ship Navy stems from estimated strategic requirements at about 2020 and beyond, not from operational requirements today.

During the 1980s, the Navy procured an average of 17 ships per year. During the 1990s, the number fell to 7 per year and reached a low of 4-5 per year during 1994-1999. During 2000-2004, the number rose slightly to 6 ships per year, and during 2005-2008 it is scheduled to average 8 ships per year. From 2009 onward, the shipbuilding rate is scheduled to rise, although the President's FY2006 Budget Submission reduced the Navy's program by three Virginia class submarines and two DD(X) destroyers between FY2009 and FY2011.

Beyond replacing aging vessels that must be retired, the Navy must also build enough new ships to generate force expansion at the desired rate: an average of 4-6 new ships must be added to the inventory each year to reach 375 ships by 2022. **Table 3-4** shows the anticipated Navy shipbuilding rates per year from 2006 through 2032. This interaction of requirements for replacement and expansion yields the projected shipbuilding schedule. A noteworthy feature is that ship production starts slowly and accelerates later: it leaps upward from 9 ships in 2008 to 12 ships in 2009, and it remains at 13-15 ships through 2019. During 2020-2025, it hovers around 10 ships, and then declines to 7-8 ships per year from 2026-2033. The reason for this slow take-off is not constraints on shipyard capacity, but a constrained Navy shipbuilding budget. It is limited today but the Navy is counting on it rising later in this decade. The result is a big bow-wave of increased procurement expenses by 2009-2010 that stays high during the following decade. If the upward surge of funding forecast for 2009 materializes, it still will not translate into a comparable increase in ship inventory until 2016. During 2010-2022, 171 new ships are funded, but the combination of slow shipbuilding and scheduled retirements results in the posture growing by only 67 ships, from 308 to 375.

Year	Annual Shipbuilding	Year	Annual Shipbuilding
2006	7	2020	11
2008	9	2022	10
2010	13	2024	10
2012	14	2026	7
2014	13	2028	7
2016	15	2030	7
2018	14	2032	7

Table 3-4. Forecasted Navy Shipbuilding Rates, 2006-2032

The specific ships scheduled to be built are listed in **Table 3-5**. During 2006-2022, four carriers and 14 amphibious assault ships are programmed to be built. Surface combatants account for 120 ships or 40% of the plan. Of these, 56 are LCS ships, and 64 will be DD(X) destroyers or CG(X) cruisers. Next, 39 SSN submarines are scheduled to be purchased by 2022, and orders to replace nearly the entire fleet of 55 submarines are to be placed by 2033. Funding of eight new SSBN submarines to replace Trident boats is planned during 2023-2033. During 2006-2022, 63 support ships are to be funded, but only 14 are programmed over the following decade. Overall, this plan would fund 207 new ships during 2006-2022, and 87 new ships during 2022-2033, for a total of 294 ships: enough to modernize the current fleet, enlarge it to 375 ships by 2022, and sustain it at about this level through 2033.

Type of Ship	Number Constructed		
	2006–2022	2023–2033	Total
CVNs	4	3	7
SSNs	39	13	52
SSBN(X)	0	11	11
Surface Combatants	87	33	120
Amphibious Ships	14	13	27
Logistic Ships	34	11	45
Mine Warfare Ships	14	0	14
Other Support Ships	15	3	18
Total	207	87	294

Table 3-5. Navy Shipbuilding Plan

Costs for Modernization and Expansion. Most of the warships in the program are expensive and make this long-term expansion plan costly. The Navy estimate is that this procurement plan will require an average of $15 billion per year (FY2005 constant dollars) during 2006-2009, $18 billion per year during 2010-2014, and $15 billion per year throughout the period of 2010-2033. This estimate is based on the assumption that the Navy will successfully pursue various fund-saving (*not* cost saving) strategies to include split funding of new large deck ships, research and development funding of lead ships for new classes of ships, and multi-year contracts. If this

estimate holds, the entire shipbuilding program will cost about $275 billion through 2022 and $450 billion through 2033 (FY2005 dollars).

Scheduled procurement of new aircraft carriers and amphibious assault ships contributes $2-3 billion per year. A bigger contributor is the cost of building new surface combatants and submarines. The new DD(X) destroyer is estimated to have an average unit procurement cost of $1.9 billion in FY2005 dollars. A CG(X) cruiser likely will cost more: about $2.5 billion apiece. If a fleet of 40-50 destroyers and cruisers is bought by 2022, total costs could be in the vicinity of $100 billion. If the small LCS cost holds at only about $250 million apiece, a fleet of 56 vessels will cost about $14-16 billion. If the Virginia-class submarines cost an average of $2.5 billion apiece, a buy of 39 submarines by 2022 will cost about $98 billion. The effect is a shipbuilding program with costs that rise from about $10 billion in 2005 to a peak of $19 billion in 2011 and remain at comparably high levels for many years.

As these cost figures suggest, the need for growing shipbuilding budgets does not derive from any single category of ships, but instead from several different categories acting together. The cost of big-deck carriers and amphibious assault ships account for only about 20% of the expense. In order to sustain the current numbers, a new carrier must be funded every 3-4 years and a new amphibious assault ship, every year. Even so, the costs of buying about 5 carriers and 20 amphibious assault ships will not be largely responsible for growing shipbuilding expenses during the next two decades. If one carrier and four amphibious ships are removed from the plan, the Navy's total shipbuilding budget will decline by only 5% or less in this period.

A similar judgment holds for the projected enlargement of the Navy's inventory toward 375 ships. This enlargement is mainly driven by the procurement of 56 LCS ships. But since these ships have a unit cost of only about $250 million, they account for only about $14-16 billion, or 6%, of shipbuilding expenses ahead. The implication is that if the LCS program is cancelled and the fleet grows only to 319 ships, not 375 ships, the expense for shipbuilding will still be 94% as large as the current forecast. The same holds true for mine warfare ships and logistic support ships. They do not inflate the shipbuilding budget. The main drivers of growing shipbuilding budgets are the programs to acquire new destroyers, cruisers, and attack submarines, which total about 40% of the new ships being bought but generate about 70% of the costs. Their costs of nearly $200 billion are determined by the high unit cost ($1.9-2.5 billion for each ship) and by the total numbers—87 ships through 2022—being bought.

Today, the Navy is spending about $10 billion per year on shipbuilding, an account that must cover expenses not only on new ships but also on conversions of old ships and other measures. Clearly the Navy's shipbuilding budget will need to increase as its overall annual procurement budget of $27.7 billion in 2005 must grow in order to accommodate not only new shipbuilding, but also acquisition of new combat aircraft and other items. By 2011, the Navy procurement budget is projected to grow to about $45 billion in constant 2005 dollars. The 75% real increase projected during 2005-2011 will enlarge the procurement funds available to the Navy provided it actually occurs and is sustained at the necessary levels afterward. At issue is whether it will actually do so.

Analysis of Five Key Assumptions Vital to the Navy's Long-Term Shipbuilding Plan

Recently the Navy reduced its shipbuilding plan for FY2006 from seven new ships to only four ships. This cutback was a product not of changes in long-term plans, but instead of disputes with Congress and OMB over whether some initial production costs can be charged to RDT&E and whether new ships should be fully funded in one year. Even setting this aside, larger affordability questions arise about not only the period through 2011, but more importantly, beyond, when the main shipbuilding is to take place. The affordability of the Navy's long-term shipbuilding plan depends on the five critical assumptions mentioned at the outset of this chapter.

If one or more of these key assumptions do not hold up, and all are highly uncertain, the shipbuilding program will be under even greater pressure than currently envisioned. The five assumptions are analyzed below with an eye on their cumulative impact on the resources that are likely to be available for shipbuilding.

Will the DoD budget experience the real growth now projected through 2022, and will its procurement budgets grow significantly? In constant 2005 dollars, the defense budget (Budget Authority, or BA) has risen from $329 billion in 2000 to $403 billion for 2005 (FY2005 dollars). DoD had planned on an increase of about 2.5% per annum to $443 billion by 2009, thereby providing about $40 billion of real growth. (**Table 3-6** below.) If the defense budget continues growing by 1-2% annually in real terms after 2009 while also rising to offset inflation (estimated at 2.5% per year), this will further elevate it by 14-29% in real terms by 2022, thus providing a steady stream of additional funds much of which is planned to be channeled into investment.

	1998	2000	2002	2005	2007	2009
Budget Authority (BA)						
Current $	258.6	290.5	345.6	402.6	444.9	488.9
Constant 2005$	308.0	328.8	369.9	402.6	424.1	443.0*
Outlays						
Current $	256.1	281.2	332.1	429.6	426.9	467.9
Constant 2005$	304.3	318.5	354.7	429.6	407.4	424.5

**The 2009 forecast for Budget Authority (BA) assumes about 2.5% annual real increases during 2005-2009. If the annual rate of increase is only 1% per year, the BA for 2009 will be $419 billion in constant 2005 dollars.*

Table 3-6. Trends in Peacetime DoD Budgets

(Does not include reductions due to the President's FY2006 Budget Submission)

Such real increases, however, seem unlikely in the short term. For the longer term, the trends are not likely to change. A recent Congressional Budget Office (CBO) study, The Long Term Implications of Current Defense Plans: Summary Update for Fiscal Year 2005, forecasts only a total 3-4% increase in real defense spending over the *entire period* of 2010-2022. This amounts

to only one-third of one percent per year. The main reason for this low-growth forecast is pressure on the federal budget from persistent deficits coupled with big increases in the costs of entitlement programs: e.g., costs for social security and health care which are projected to double in the next 10-15 years in real terms. If so, currently projected funds may well not be available for growing defense budgets even if DoD has a legitimate requirement for them.

Trends in DoD's future top-line are important because they will have a major bearing on the amount of funds that can be devoted to DoD-wide procurement for all services, including the Navy. During the 1990s new weapons did not have to be bought because inventories were relatively modern and the threat from the Soviet Union had vanished. Today, the aging of these weapons and in some cases, the mismatch of their capabilities to emerging challenges makes necessary the onset of a lengthy new period of extensive procurement affecting all services.

DoD has been developing a new generation of weapon systems that is now poised to exit RDT&E and enter procurement in the coming years. This includes not only new ships, but also new combat aircraft, ground weapons, and supporting systems. Procurement of these new weapons is just beginning, and is scheduled to accelerate in 2011, thereby creating a large "bow wave" of procurement expenses during the following decade. In order to fund these new weapons, DoD recently has been striving to increase its procurement budgets. During the mid-1990s, DoD's procurement budget dropped to $48 billion in constant 2005 dollars. Since then, the procurement budget has grown to $74.9 billion in 2005, and, before the President's FY2006 Budget Submission, was programmed to rise to $106 billion by 2009 (constant 2005 dollars) (**Table 3-7**). The Services have been counting on this $31 billion per annum increase to cover procurement of new weapons that they have programmed.

Category	Projected Expenditures Percent Increase				Percent of Budget		
	2005	2009		2005–2009	1990	2005	2009
Military Personnel	$106.3	$108.4	+	2.0%	27%	26%	25%
O&M	$141.2	$147.2	+	4.2%	30%	35%	34%
Procurement	$74.9	$105.8	+	41.3%	28%	19%	23%
RDT&E	$68.9	$65.4	-	5.1%	12%	17%	14%
Construction, Housing, Other	$11.3	$16.2	+	43.4%	3%	3%	4%
Total	$402.6	$443.0	+	10%			

(BA in Current $ Billion)

Table 3-7. Projected DoD Budgets and Spending Patterns

(Does not include reductions due to the President's FY2006 Budget Submission)

The prospect of little real growth in DoD's overall budget during 2009-2020 means that, all other things remaining equal, the DoD procurement budget also will remain flat, perhaps rising to offset inflation but not providing the substantial growth the services have assumed in building their long term programs. Whether annual procurement budgets of $100 billion (in constant 2005 dollars) will be adequate to meet requirements for the coming bow wave is uncertain (details are

discussed later). Equally uncertain is whether even the reduced procurement budget of about $100 billion can be achieved by 2009 and maintained afterward. The other major categories of defense expenses must also be funded. As **Table 3-7** shows, the projected rise in procurement spending by 2009 is based partly on the assumption that expenses for military personnel and operations & maintenance (O&M) will rise only by 2-4% in real terms.

Is this assumption valid? There are grounds for concern. If the Army grows by 40,000 active troops, for example, DoD's military personnel budget will need to rise by about $2 billion per year and its O&M budget will rise by another $2 billion per year. Even short of force expansion, O&M spending could prove higher than now forecasted: the annual growth rate for 1995-2005 has been about 50% higher than the forecast for 2005-2009. If this reining in of O&M expenses is not achieved, there would have to be cutbacks elsewhere, most likely to procurement budgets. Disproportionate cuts in procurement budgets are prominent in the President's FY2006 Budget Submission.

The uncertainties ahead for the FYDP of 2006-2009 magnify when the lengthy follow-on period of 2010-2020 is considered. If virtually no real increases in the defense budget are funded, DoD will be able to generate annual procurement budgets of $100 billion in FY2005 dollars only if it succeeds in preventing the other accounts from rising. This is unlikely. In the absence of cutbacks elsewhere, expenses for military personnel and O&M seem likely to continue their real growth during 2010-2020: both categories are influenced by larger, cost-increasing changes taking place naturally in the national economy, rapidly growing healthcare costs to cite one. Even if expenses for these accounts can be held to increases of 1% annually in real terms (very low by historical standards), they will require an additional $30 billion by 2020, and an average of $15 billion annually during 2010-2020. The effect would be to put pressure on the procurement budgets for the decade (up to 15%): a large cutback for budgets that already are fully taken up by the coming bow wave. In order to avoid this fate, DoD will need to tighten its belt in O&M and other areas. Perhaps it will do so, but until then, future procurement budgets will be a variable in the calculus not only for DoD as a whole, but for the Navy as well.

Will Congressional supplementals continue to fund wartime expenses in Iraq and Afghanistan, or will those costs bite into the core DoD budget? Thus far, DoD's wartime expenses for Iraq and Afghanistan have been funded through Congressional supplementals: $62 billion for 2003, $68 billion for 2004, and at least a similar amount for 2005. The effect has been to swell total spending to about 15% higher than would be needed for normal peacetime spending: e.g., to $441.7 billion in 2003 (current dollars) rather than the $379.6 billion originally requested. Because supplementals have freed DoD from drawing upon its core peacetime budget, it has been able to pursue modernization and most operations typical of peace time even while fighting two wars abroad. If the intensity of combat operations in Iraq and Afghanistan lessens in the coming years, the need for further supplementals of this magnitude will decline. But if these operations continue apace, or are replaced by other contingencies, total defense spending will need to remain higher than the programmed budgets by 15% or more. Additional supplementals will be needed to make up the difference.

Will Congress continue to be willing to authorize supplementals to fully make up the difference between wartime requirements and growing peacetime budgets? If wartime expenses remain high, Congress may prove less willing than now to fund both these expenses and fully fund the ongoing defense program at the same time. To the extent this is the case, even a shortfall of $10-20 billion annually could damage DoD's investment budgets, the likely target of reprioritization, by draining away 7-15% of their funds. The Navy's planned shipbuilding budget could be expected to be taxed as well.

Will the Navy receive the shares of DoD's overall budget and procurement budget envisioned by its shipbuilding plan? As the following table shows, the Navy has benefited proportionally from the growth of the DoD budget since 2000, and it is projected to benefit from further growth through 2009 (**Table 3-8**). The real spending increases—averaging about 3.5% annually for both DoD and the Navy during 2000-2009—are high when judged by historical standards. They have greatly increased the resources available to DoD and the Navy has received about 30% of the DoD budgets. The yet larger budgets projected for future years play a major role in the Navy's assumption that it will be able to increase its annual procurement budget from $27.7 billion in 2005 to $45 billion by 2009 (in constant 2005 dollars). During 2005-2009, the Navy's procurement spending will roughly match the USAF's spending ($170 billion) and greatly exceed the Army's spending of $68 billion.

	2000	2005	2006	2007	2008	2009
Current Dollars						
DoD Budget (051)	$290.5	$402.6	$423.7	$444.9	$466.8	$488.9
Navy Budget	$88.8	$119.2	$125.4	$130.1	$137.3	$148.0
Constant 2005 Dollars						
DoD Budget (051)	$328.8	$402.6	$413.8	$424.1	$433.8	$443.0
Navy Budget	$100.2	$119.2	$122.6	$124.3	$128.1	$134.9
Navy Share of Budget	30.5%	29.6%	29.6%	29.3%	29.5%	30.5%

($ Billions)

Table 3-8. DoD and Navy Budget Trends: 2000-2009
(Does not include reductions due to the President's FY2006 Budget Submission)

Will the Navy continue to be awarded about 30% of the defense budget not only through 2009, but afterward? During the Reagan buildup of the 1980s, the Navy's share of the budget swelled to about 34%, but as the 1990s unfolded, it shrunk to the current level. The Navy's need to modernize its inventory might qualify it to preserve an equal share of the budget in the future. But the other services and defense programs also need greater funds as the U.S. military endeavors to carry out expeditionary operations in the near-to-mid term while transforming for the long term. Over the longer term, OSD is examining the imperative of shifting its attention increasingly to the non-traditional challenges that have dominated military activities during the past decade. Resources shifted to combating non-traditional threats can be expected to reduce funds available for ship construction among other large capital intense programs focused on traditional threats. The President's FY2006 Budget Submission takes a step in this direction.

A parallel uncertainty is whether the Navy will receive the share of DoD's procurement budgets that is needed to fully pursue its shipbuilding plans. The reason is not just the shrinking of the currently projected procurement budgets DoD-wide. It is also competition from other programs during a period in which costs for them may rise above current estimates.

Will the Navy be able to restrain growth in its O&M spending? The Navy's plan to increase its procurement budget in order to fund its planned shipbuilding program depends on its success in reining in spending for Operations and Maintenance. To the extent it falls short, planned shipbuilding budgets will have to be cut. The stage for examining these cost-reduction efforts can be set by briefly examining trends within the Navy's budget. As the following chart shows, the Navy's budget is projected to grow to $134.9 billion by 2009 in constant 2005 dollars (**Table 3-9**). Today, Navy spending on O&M is similar to the Army and USAF: each service spends about $35 billion per year. The Navy's annual per capita spending of $64,000 is lower than that of the Army ($69,000) and USAF ($100,000).

	2005	2009	Percent Change
Military Personnel	$36.9	$36.5	- 1.1%
O&M	$35.1	$33.6	- 4.3%
Procurement	$27.7	$46.6	+ 68.2%
RDT&E	$16.3	$11.1	- 31.9%
Construction & Housing	$1.11	$2.0	+ 81.18%
Other	$2.1	$5.1	+242.9%
Total	$119.2	$134.9	+13.2%

(BA, Constant 2005 $, Billions)

Table 3-9. Trends in Navy Budgets, 2005-2009

(Does not include reductions due to the President's FY2006 Budget Submission)

During 2005-2009, the Navy's procurement budget was slated to grow to $46.6 billion before the President's FY2006 Budget Submission, an increase of $18.9 billion or 68.2%. The increase through 2009 depends on growth in the Navy's total budget, but also on cutbacks in RDT&E and restraint in the growth of O&M spending. O&M spending is projected to *decline* by 4.3% in constant dollars, compared to the projected DoD-wide 4% increase. Both of these reductions reflect conscious choices by the Navy aimed at providing more funds for procurement. If the Navy RDT&E budget remains at current levels and its O&M spending rises by 17% (the DoD-wide trend), the former will be $5.2 billion higher in 2009, and the latter will be $5.3 billion higher. Procurement spending for 2009 would be commensurately less: closer to $36.3 billion instead of $46.6 billion.

Funding cutbacks of this sort could well lead to a disproportionate reduction of the shipbuilding budget not only because of the top-line impact, but also because of the likely impact on how the Navy's procurement budget is distributed. As shown in **Table 3-10**, the Navy's current procurement budget allocates only $10 billion to shipbuilding. The remaining $17.7 billion is distributed among other accounts. Fully $8.8 billion is spent on procuring aircraft, the F/A-18 E/F, the V-22 Osprey, MH-60 helicopters, and E-2C Hawkeye. Another $8.9 billion is spent on

all other procurement: ammunition, missiles, small craft, shipboard equipment, communications and electronics, etc. If the Navy is to fully fund its shipbuilding plan in all categories, annual procurement spending on new ships must rise to about $16 billion in 2009 and to $20 billion by 2011 (in constant 2005 dollars), and must be sustained at comparably high levels over the following years. Cutbacks in total Navy procurement budgets could lead to disproportionate cuts in shipbuilding because the Navy would be hard-pressed to squeeze savings out of many small programs for secondary items and related assets and to impose proportionate reductions on its expensive air modernization for the Navy and Marine Corps. A 15% reduction to the Navy's total procurement budget could plausibly translate into a reduction of some 25% in the shipbuilding budget.

Component	Funds
Aircraft Procurement, Navy	$8.8
Weapons Procurement, Navy	$2.1
Procurement of Ammo, Navy and Marine Corps	$0.9
Shipbuilding and Conversion, Navy	$10.0
Other Procurement, Navy	$4.8
Procurement, Marine Corps	$1.2
Total	$27.7

(BA, $ Billions)

Table 3-10. Navy Procurement Budget 2005

If the Navy's procurement budget though 2009 were to rise by only as much as the DoD average (i.e., by 41% rather than 68% as now planned), the Navy would have $7.6 billion less than it now plans to spend on procurement in 2009 and about $100 billion less cumulatively over the course of 2009-2022. The Navy is counting on this extra funding wedge being available. It finances fully one-third of its shipbuilding plan during these years. Conversely, the Navy could conceivably be compelled to reduce its shipbuilding plan by one-third or more if this wedge does not materialize.

Are the Navy's plans to keep a tight rein on O&M spending realistic and achievable? The need to address O&M spending is not unique to the Navy. The peacetime O&M budget, including the services and all DoD agencies, has soared to $141 billion in 2005. This has produced O&M costs per active serviceman of nearly $100,000, which is far above the per capita cost of $57,000 in 1980 (measured in constant FY2005 dollars). The causes of this major increase are manifold, but they do not stem from any major increase in the cost of training active combat forces, which costs only about $25 billion annually. Thus far, DoD's main effort to control O&M costs has come through Base Realignment and Closures (BRAC), which endeavors to eliminate surplus bases and facilities. The BRAC process, which produces increased transition costs in the near term in exchange for greater O&M savings in the long term, has been largely stalled for several years. Further savings may be possible when new BRAC measures are announced in 2005, but even so, the impact on solving DoD's problem of high O&M costs is likely to be helpful, but marginal. A larger, multi-pronged O&M effort will be needed if the Navy's planned O&M savings are to be realized.

The Navy stands at the forefront of DoD attempts to trim O&M spending. Its O&M budget is projected to fall by 4.3% through 2009, while the DoD-wide O&M is projected to increase by 4%. If Navy O&M spending grows at a rate that matches the average DoD increase, Navy procurement spending could lose up to $3 billion in 2009, and $40 billion cumulatively throughout 2009-2022. Tight economizing on O&M spending seems likely to be hard for the Navy because it already is more efficient in this arena than the Army and USAF, and fully 75% of its O&M spending is devoted to active operating forces, whose high-tempo activities will be hard to trim in the foreseeable future. Although the Navy's attempt to rein in O&M spending is a goal well worth pursuing, the risk of falling short is worth keeping in mind mainly because, in recent years, few efforts to cut O&M spending growth have succeeded. It is even questionable if DoD can *limit* overall O&M spending increases to 4% through 2009. Whether the Navy can *reduce* its own O&M expenses by 4.3%, during a time when it likely will be operating at a high tempo, seems unlikely. As matters now stand, the Navy's goal of a 4.3% reduction in O&M spending is a worthy aim, but a savings that cannot be counted upon.

Will the Navy succeed in controlling the construction costs of its new ships? The projected costs of the Navy's shipbuilding plan are high because the unit cost of most of its new ships is high. The new DD(X) destroyer is projected to cost about $1.9 billion apiece, the new CG(X) about $2.5 billion apiece and the Virginia class submarines $2.5 billion apiece. These cost estimates gives rise to the overall forecast that a shipbuilding plan of 207 ships is likely to cost about $275 billion in constant 2005 dollars.

It is important to note that all of these cost estimates are made in the face of uncertainty: many of them deal with ships that will not enter production for several years and will be deployed several years later. In recent years, DoD has taken steps to ensure that cost criteria and goals are incorporated into acquisition contracts. The effect has been to lessen the proclivity of new weapons to experience soaring costs as they move down production lines. While cost inflations of 75-100% may now be confined to history, this does not mean that today's new weapons are invulnerable to inflation. Costs can still rise for several reasons. The relatively low inflation of ship construction costs factored into the DoDs plans may well be exceeded. For example, raw materials and labor can turn out to be more expensive than originally anticipated.

Even with a strong effort to control costs, Navy shipbuilding is vulnerable to potential cost inflators. Moreover, the DD(X), CG(X) and Virginia class SSNs are being designed to provide multiple different types of combat capabilities in one package. The need to ensure that all of the new weapon systems are integrated and operate together at high effectiveness opens the door to potential cost growth. For many ships, multiple new components are being designed, all of which must be integrated into a complex system. Such sweeping innovations may carry the potential of higher costs than originally estimated.

If cost increases are experienced, how large might they be? This question cannot be definitively answered because too little is known about the new ships that will enter production in the coming years. Experienced naval analysts point to historical experience of an average cost increase of 25% for a new class of ships. Some programs, like the LPD-17, could even exceed this.

The Navy may be shortchanging its future RDT&E to maintain its procurement budgets. The Navy is taking a risk by reducing RDT&E spending by fully 32% during a period in which the U.S. is entering an unstable and less predictable security environment. The Navy's ability to increase capabilities in the fleet while controlling cost could be unduly compromised. In addition, RDT&E costs for new vessels with visionary, untested technologies that rise above current plans, compel at least steady, if not increased, demand for resources for RDT&E. This risk seems real enough to be taken seriously. The CVN-21 carrier, the DD(X) destroyer, and the LCS are still early enough in their RDT&E cycles for cost inflation to occur. In addition, the Navy's participation in the F-35 JSF fighter program—it is seeking to create specialized CTOL and VSTOL models—leaves it vulnerable to increased RDT&E spending on air modernization. Perhaps a deep cut in Navy RDT&E will prove attainable but intuitively, an uncertain future and the need to find ways to deliver greater capabilities at lower cost argues for a robust RDT&E program to ensure the Navy has options available to it to react to a dynamic security environment.

Gauging the Future—Preparing for Less Optimistic Outcomes

The bottom line is that because several fluctuating variables are at work, and their trends are murky, no single-point forecast can confidently predict the future 10-20 years from now. That said, all of the issues analyzed above point toward downward pressure on the availability of resources for shipbuilding.

A somewhat pessimistic, though realistic, case is that a combination of a drop in procurement funds for shipbuilding and some cost growth could leave the Navy with only a modest growth in its projected shipbuilding budget. Extrapolating the trends set in motion by the President's FY2006 Budget Submission, the Navy could realize only about 60% of the procurement budgets needed to fund the current shipbuilding plan. A 40% shortfall results in a program to build about 130 new ships, and its future fleet falls to about 300 ships, with a range of about 270-315 ships, depending upon the exact mix of ships to be purchased and deployed.

The Navy has a much more numerous fleet architecture in mind. This underlines the importance of developing a fleet architecture underpinned by a shipbuilding program that preserves options to adjust rapidly in the event of a change (for the better as well for the worse) in the availability of resources. This points to the imperative of having ships that can be built more rapidly at a lower unit cost. Examples of alternative future fleet platform architectures that capture these features are presented in **Chapter 6** (**Examples of Fleet Platform Architectures**).

4. Technology Opportunities

Introduction

This chapter highlights important advances in technology that open up new opportunities for the U.S. Navy to design and field a powerful fleet adaptable to the broad spectrum of challenges it will face in the coming decades. The Navy's ability to maintain the nation's ***strategic advantage*** at sea can be balanced with an ability to provide the maritime power to conduct or support intervention on land. To support ***joint expeditionary operations***, the fleet must have the requisite capabilities for control in the littorals, force projection, and support of forces on land.

The emerging theory of ***network-centric warfare*** (***NCW***), including the important advantages available to the warfighter through the full or partial implementation of network-centric capabilities, networking at all levels of military operations, and networked behavior, provides the basis for one of the key design principles for developing an ***alternative fleet platform architecture***. Networking allows for a modular, building block approach to military scaling with applicability across a broad spectrum of missions. Furthermore, the architecture of a fleet with dispersed, networked surveillance, weapons and command and control (C2) assets means that platform size can be reduced, while still increasing performance through networking and increased numbers of platforms. As platform size is decreased, advances in precision and terminal blast effects hold the potential to maintain firepower without losing lethality. Technologies are being developed to: lighten the payload, thereby extending the endurance and range of unmanned systems; provide robust data links and integrated sensors to detect and target low signature threats; and provide electronic warfare (EW) technology and anti-submarine warfare (ASW) technology tailored to threats in the littoral.

Breakthroughs in technology provide the Navy with the opportunity to leap ahead to deliver a fleet far more capable than the programmed fleet. High leverage technologies and the potential payoff they offer the fleet are shown in **Figure 4-1**.

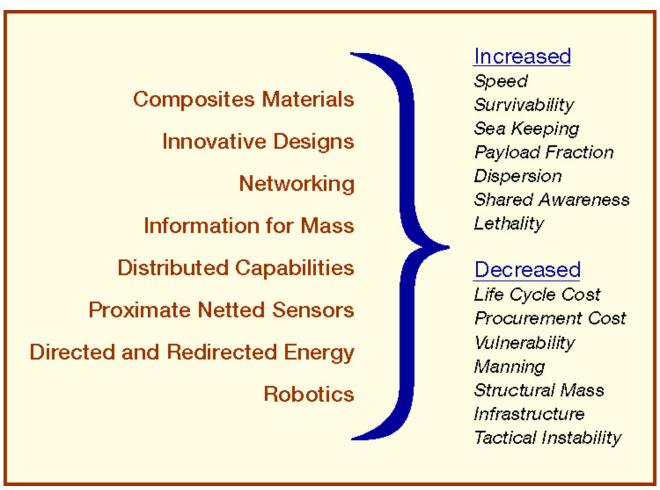
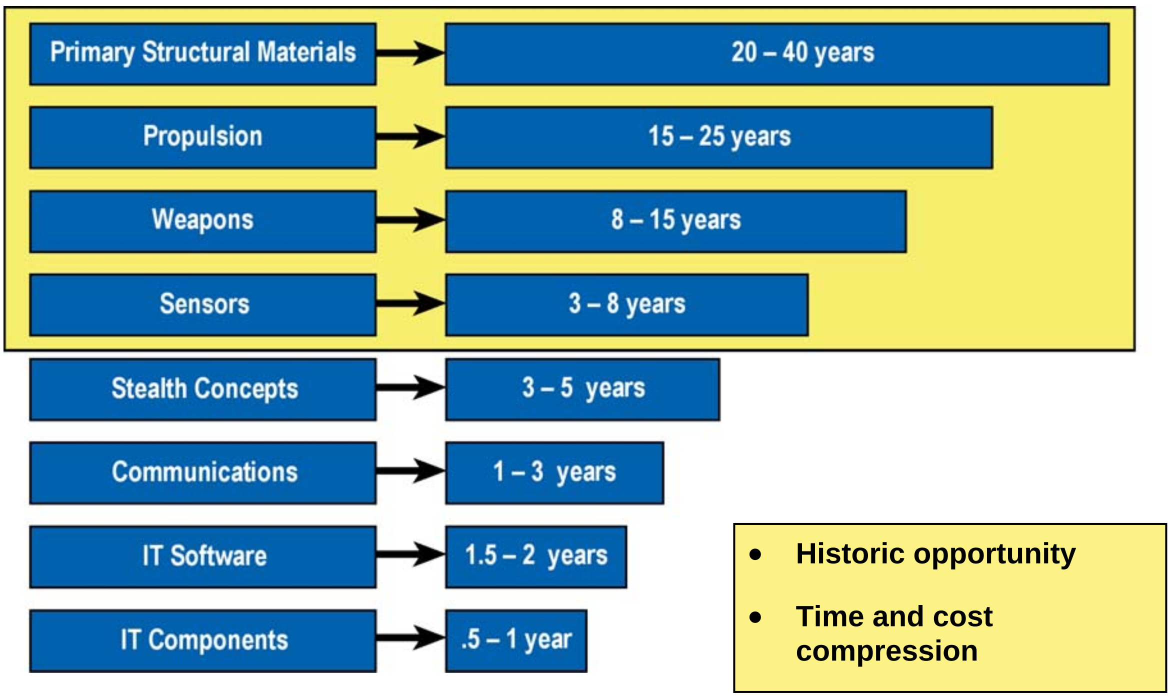


Figure 4-1. Technology…Opportunities and Payoff

The examples of alternative fleet platform architectures presented in **Chapter 6** of this report were designed to take advantage of the short cycle times for information-based technologies. **Figure 4-2** below shows the typical cycle times required for meaningful advances in key technologies useful to the Navy. Despite the fact that they have longer cycle times than areas such as ***communications***, ***IT software***, and ***IT components***, key technology areas like ***primary structural materials***, ***propulsion***, ***weapons***, and ***sensors***, should not be ignored. In fact, in materials and propulsion areas in particular, research has brought the shipbuilding community to an inflection point. Breakthroughs in composite materials and advanced propulsion have matured these technologies to the point where they are ready to be exploited in the next generation of ships. Accordingly, we are entering a window of opportunity to accelerate incorporation of advances in materials, propulsion, weapons, and sensors.



Source: Naval Research Advisory Committee

Figure 4-2. Technology Trends and Cycle Times

Technology Opportunities

The principal driver for a powerful fleet that can adapt to a broad spectrum of challenges is a networked system that derives its power from the integration of all the elements in the network, greatly amplifying the individual capabilities of the nodes. Advances in technology hold promise for a networked fleet in which sensors can be distributed and integrated to sense the environment and provide a common operational picture. Weapon speed can be traded off against distributed loitering weapons or a widely dispersed set of weapons that always have a shooter near the target. Greater targeting precision is possible from networked sensors resulting in smaller miss

distances; hence smaller warheads suffice. Such a system is synergistic to an architecture of networked small ships with small weapons that maintains required target coverage.

Technology Priorities

The ***alternative future naval fleet platform architectures*** presented in **Chapter 6** draw considerable power from the design concept of networking. The benefits of a networked fleet are derived from dispersed assets that provide broad coverage, rapid threat response, and modularity and scalability of assets. Technologies to achieve these benefits and that merit priority attention are those that enable robust and scalable networks including sensor, command and control and weapons elements. This leads to an accent on affordable surveillance and sensor components, smaller ships with longer endurance and higher payload fraction, lighter-weight weapons and stealthy unmanned systems.

The following list provides priorities for high payoff technologies supporting network-centric fleet architectures. These technologies are subsequently described in more detail.

- **Networks and Distributed Capabilities.** Mobile, self-forming, reconfigurable networks; high bandwidth secure data-links; and distributed collaborative tools for decision making.

- **Advanced Netted Sensors.** Multifunction radio frequency (RF) systems, synthetic aperture radar, ladar, hyperspectral infrared (IR) seekers, and advanced missile seekers.

- **Innovative Hull Designs, Efficient Propulsion, Composite Materials and Robotics**.

- **Unmanned Air Vehicles.**

- **Underwater Surveillance and Weapons.**

- **Advanced Weapons Concepts.** High energy lasers (HEL), and electromagnetic launch (EML) guns.

- **High Risk / High Potential Payoff Technologies.** Nanotechnology and biotechnology

Technologies for the Future

Technologies that support a fleet architecture that is networked and dispersed, incorporating smaller platforms with modular payloads, promise high payoff. Advances in commercial IT and other technology provide an opportunity to leverage.

Networks and Distributed Capabilities. Networks are the enabling framework for future naval architectures. In turn, networks are enabled by the revolution in information technology, largely fueled by the commercial marketplace. The key to success is establishing and maintaining a dynamic mobile network that includes information gathering, processing, and distribution.

- **Mobile, Self-forming, Reconfigurable Networks:** Untethered networks enable distribution of information at high data rates across broad areas on-the-move. In an un-tethered network, all devices are mobile, including routers and servers. The network is self-organizing in an ad-hoc but transparent and energy aware fashion.

- **High Bandwidth Secure Data-links:** Data and communications links provide the backbone for NCW. Significant recent and ongoing technology developments are evident in the following areas: improving bandwidth, reducing the probability of intercept, and multi-level security. Demands on bandwidth can also be reduced by processing data at the sensor rather than centrally. As computing power per unit volume continues to increase, this approach will be increasingly effective. Laser communications offer the prospect of greatly expanded bandwidth. Today, they must maintain line of sight connectivity though research on laser relay is moving to make its use practical.

- **Distributed Collaborative Tools for Decision Making:** Networking can produce a flattened command structure with a rapid decision cycle. Information can move rapidly out to the edge of the network, which is to the tactical-level end-user. While network technology provides the ability to move information rapidly outwards, allowing distributed decisions, it also allows for interactive decision-making throughout the network. High-speed decision-making and the ability to provide command and control to dispersed joint forces, including unmanned systems, is an operational challenge that technology can help to solve. Decision aids (computer-aided reasoning), human-machine interfaces, and collaborative tools can enable rapid decision making at the right command levels.

Advanced Netted Sensors. Advanced sensors with high-speed signal- processing address the need for tracking, target identification and clutter rejection. Sensor technology is advancing in parallel with developments in semi-conductors, large scale integrated circuits, and advanced on-chip signal processing. In the past the functions of surveillance, tracking, and terminal guidance from weapon seekers were performed sequentially with distinct systems.

A high payoff opportunity therefore is to combine the functions of surveillance, tracking, terminal guidance and even fusing of the warhead through advanced multi-function sensor concepts and the networking or fusion of distributed sensors to provide enhanced coverage, resolution, and counter-countermeasures. Examples of surveillance, tracking and targeting technologies that hold high potential include multifunction radio frequency (RF) systems, synthetic aperture radars (SAR), ladars, hyperspectral infrared detectors, and advanced missile seekers.

- **Multifunction RF Systems:** The utility of multifunction RF emitters and receivers would be in combining many of the antennas on a ship into fewer apertures. Currently on a ship every RF emitter has its own individual components. There are separate systems for every RF function: surveillance, fire control, navigation, EW, and communications. These functions cover a wide spectrum of the RF frequency band, and have different waveforms and power levels. Advances in wide-bandgap semi-conductors and software-controlled electronically-steered arrays (ESAs) allow the sharing of functions in a

common aperture. Advantages of the concept are sharply reduced topside hardware and signature reduction. The concept also allows for reduced power consumption, maintenance and operator training. These features would further make it possible to put this capability on small ships.

- **Synthetic Aperture Radar:** SAR and inverse synthetic aperture radar (ISAR) have been developed to a level of common operational use; advanced signal processing has resulted in real time imagery. Future advances in SAR technology could lead to employment on a small UAV in which a loitering vehicle could have a SAR search and targeting mode reserved to large aerial vehicles today.

- **Ladar:** A ladar uses the same principles as radar but uses visible or IR instead of RF. Application of this technique provides very high resolution that could make it very useful in a cluttered (e.g. urban) environment. The ladar could be mounted on a loitering UAV to identify a target when cued by a wide area search system.

- **Hyperspectral IR Seekers:** Hyperspectral seekers can provide the information necessary to discriminate a target from a cluttered background and by collecting imagery at multiple "lines" or frequencies providing unique signatures. Success in making this technology operational could provide a powerful surveillance and targeting capability in an irregular conflict where *finding* targets is typically the biggest challenge.

- **Advanced Missile Seekers:** GPS guidance provides missile guidance to hit targets with known co-ordinates. For moving targets, or where GPS is locally denied, missile seekers are required to provide the end game guidance. IR missile seekers, for example, currently employed require cryogenically cooled detectors and precision stabilizing gimbal systems. This translates into high cost and large volume. IR seeker research and development is in progress for uncooled seekers with simple pointing mechanisms to solve both problems. Coupled with advances in on-board signal processing, the raw image of a low cost seeker can be greatly enhanced.

Innovative Hull Designs, Efficient Propulsion, Composite Materials and Robotics. The conceptual framework of a fleet architecture with greater numbers of dispersed networked assets is significantly different from the current fleet of large, highly integrated multi-mission warships. This architecture is enabled by faster, more maneuverable ships with a high payload fraction that, though smaller, have sea keeping qualities previously reserved for larger ships.

Supporting intervention on land will require special capabilities for both amphibious and logistics ships and Navy heavy lift aircraft. A means of morphing from the deep draft needed to carry big loads in the open sea to a shallow draft needed to enter shallow ports would speed the employment of forces. If the lighter is a separate ship, a means is required for transferring heavy unit loads to and from a larger ship in the open sea. An addition or alternative to lighters is having heavy lift aircraft that can operate from carriers or other air-capable ships. Heavy lift aircraft that can operate off large deck ships could provide logistics support as well as weapon delivery, airborne surveillance and command and control, and even airborne tanking. Research on jet powered VSTOL aircraft such as the AMC-X shows promise on delivering this capability.

Ship design is generally a sub-optimization of desired attributes that include speed, sea keeping (across different speeds and different sea states), load fraction, survivability against attack, draft (ability to operate in shallow water), range between refueling, maintainability, and required operational manpower. Technological advances that address these desired attributes include advanced hull shapes, dynamic control for sea keeping, drag reduction techniques, stealth, advanced materials, propulsion and automation.

- **Hull Forms:** Hull design is the dominant factor in ship speed, payload capability, sea keeping and draft. It also is a major factor in the ship's radar and acoustic signatures. Several innovative technologies address the complex optimization of speed, stability, and draft. The Trimaran, with a long narrow main hull to diminish wave drag, maintains its stability with "outrigger" hulls, whose waterplane area provides stability at the expense of some additional drag.

  Another option to reduce wave drag is to eliminate much of the ship's beam at the water line by either lifting the ship out of the water or by submerging much of the hull below the water surface. Advanced hull forms exploiting these concepts are hydrofoils and the SWATH ships (Small Waterplane Area Twin Hull). Both have had successful applications but they both suffer from high sensitivity to weight variations and, in the case of the hydrofoil, high dynamic loads, and in the case of the SWATH, increased friction because of the immersion of both hulls.

  Promising new technologies include underwater lifting surfaces with dynamic control that lifts the hull to reduce drag yet maintains stability in high sea states even with weight variations. Technologies to keep the boundary layer from becoming turbulent include introducing fluids into the boundary layer or even applying suction. To date none of these techniques has been made operational but the payoff for low friction drag could be an 80 knot ship.

- **Propulsion:** While gas turbine technology is relatively mature, significant payoff for smaller platforms could be realized in an "all electric" ship in which centrally generated electrical power provides not only propulsion but also energy for ship operations, communications, surveillance, and even weapons modules. While the Navy currently has priority access to petroleum-based fuels, energy shortages in the future could constrain operations. Electric propulsion would provide more options for energy sources including other hydrocarbons, hydrogen derived from the ocean, or nuclear. While large superconducting motors are still impractical, significant advances have been made in permanent magnet induction motors. Electric motors do not require the heavy gearing of gas turbines and may be podded for advanced hull designs.

- **Materials:** Incorporating lighter weight composite materials into ship structures makes higher speed ships possible. Composites and aluminum have better strength to weight ratios than steel. They offer opportunities for reduced weight, have particular applicability to smaller ships, and have already been used in other navies. Some composites offer uniform strength while others, based on advanced fibers, have excellent

strength in certain directions but not others. This complicates the structural design but has the potential of yielding very strong and stiff structures that are also very light. The technology of composite materials, already widely used in the aerospace industry, has reached the point where use in ship structures with high strength to weight ratios is practical.

- **Automation and Reduced Manning:** Reduced manning on ships has significant payoffs in reduced costs, reduced "hotel" loads affecting ship size, a higher payload fraction and fewer personnel at risk in high threat environments. Much of the automation employed in modern aviation is applicable to ship control and navigation. Computer driven dynamic control surfaces can augment ship speed and stability. Automation can also be incorporated to assist decision-making, establishing networks, and in the operation of weapon systems.

Unmanned Air Vehicles. Rapid response to a time-critical threat can be addressed with a network of loitering weapons that cover the threat area. Technology advances that are making long loiter time possible are: smaller size and weight of the vehicle to extend endurance, data links for real time targeting, high speed propulsion for response to time critical targets, terminal accuracy to maintain a high kill probability with a lighter warhead, and responsive ordnance to optimize a kill.

Three tiers of UAVs make up today's surveillance and targeting network. High altitude UAVs, such as Global Hawk, provide a broad area of coverage and have long endurance but are limited in resolution. Mid-altitude UAVs, such as Predator, provide a balance between coverage and resolution and can greatly reduce the kill time by carrying weapons such as the Hellfire missile. Small UAVs that can operate in restrictive environments are limited by onboard power required for propulsion, sensors, receivers, signal processing, and data transmission. Promising technologies to address this problem and to expand the utility of small UAVs include compact high-density energy storage, compact high-power motors/engines, small high-resolution digital visible and IR cameras, data compression techniques and small high gain antennas.

- **Strike Weapons Technology:** Technology holds promise for developing smaller lethal weapons. Key are sensors for precision terminal guidance and aim point selection and warheads that can be reconfigured to optimize blast, fragmentation, or penetration promise to enhance kill probability for a smaller missile. Progress in higher thrust-to-weight turbofan propulsion and in high aerodynamic-lift body-shaping promises to deliver further weight reduction.

- **Unmanned Combat Air System (UCAS):** The concept of an unmanned combat aircraft has progressed steadily. The first step was to take the pilot out of the cockpit to a remote operating location. The current DARPA UCAS program goes well beyond this first step and is developing a netted system of vehicles whereby the system operator does not remotely fly aircraft but provides mission level oversight. The vehicles are smaller and less costly than manned aircraft. Each vehicle has considerable autonomy but is part of the overall system of vehicles executing a mission. The program offers to enhance our

capability for deep penetrating strike, suppression of enemy air defenses (SEAD), and high threat area reconnaissance.

Underwater Surveillance and Weapons. Underwater surveillance in the littoral is a challenging problem. Both active and passive sonar are limited by bottom and surface effects, reverberation and other phenomena. Submarines powered by Air Independent Propulsion (AIP) are very quiet and can stay submerged for up to two weeks. Mines constitute a serious threat to ships and landing craft and are readily available. Non-acoustic detection technologies are necessary for both of these threats. As with networked surveillance for surface targets, underwater surveillance can be enhanced by networking distributed sensors from surface, air and underwater vehicles. A critical enabling technology for underwater networking is underwater communications.

- **Underwater Surveillance:** The littorals require alternative technologies for acoustic surveillance as well as different strategies for sensor deployment. Alternative signatures to acoustic include magnetic, gravitational, electromagnetic, and signatures related to the internal wake of an underwater vehicle that can include bio-luminescence. In very shallow water optical techniques similar to LADAR can detect bottom mines. Advances in signal processing allow for enhanced search rates which have been a limiting factor in clearing a path for forced entry. Networking of underwater sensors provides similar advantages to ASW as it does to Strike and AAW. Acoustic bandwidths are very narrow and electromagnetic signals only propagate short distances in salt water. Innovative solutions for data links are required such as the concept of underwater "modems" with above surface antennas that would serve as "cell towers" in providing a network. The communication transmission distances from submarines, UUVs, and sensors to these distributed modems would be short enough to limit transmission loss and distortion in the littorals.

- **Underwater Weapons:** To support operations and platforms in the littorals underwater weapons need to be smaller and faster than strategic heavy weight torpedoes. For short ranges, very high underwater speeds can be realized by utilizing supercavition in which a bubble of water vapor is created in front of a torpedo due to the local pressure drop in the water created by the high velocity flow of water over the torpedo. This vapor bubble greatly reduces the drag and allows very high velocities. Torpedoes fired at supersonic velocities into the water from aircraft can also utilize this principle. To both find and neutralize bottom and surf zone mines small robotic underwater crawlers are being developed that can withstand the turbulence of the surf. Specialized explosive charges are being developed for underwater mine clearing.

Advanced Weapons Concepts.

- **High Energy Lasers (HEL):** The Navy is pursuing research on high energy Free Electron Lasers (FELs) that produce frequencies better suited to propagation through the atmosphere than chemical lasers. As ships become "all electric," an FEL, run from the ship's power and would not require exotic chemical fuels. As long as a ship has fuel for power, the electric laser could fire. This provides a very "deep" magazine. An HEL might be effective against small boats, aircraft and UAVs. A particular advantage of lasers is

that their power levels can be modulated from a warning level of energy (non-lethal) to a kill level. This would provide a particularly valuable capability in the littorals cluttered environment where it is hard to distinguish a threat from a commercial or private vessel. A vessel that ignored a warning could be disabled or killed by the same HEL system.

Moderate power HELs could also be effective on an airborne platform (such as a V-22). Targets of interest could include light vehicles (potential suicide automobiles), small boats, potential IEDs, or even crowd control with a wide area beam that would dissuade approach by intense heat. In addition to FEL's, solid-state lasers are also candidates for moderate power HEL's that also run on electric power.

- **Electromagnetic Launch (EML) Guns:** The physical principle of accelerating an electrical conductor with an electromagnetic force is an area of intense research. If outstanding engineering problems can be solved the EML gun could provide a new dimension to naval fires. An EML could accelerate a projectile to hypersonic speeds in a practical gun barrel length with ballistic ranges up to a few hundred miles. At these ranges, the EML system would be competitive with small cruise missiles but with more firepower at reduced cost. The propellant energy is electric so the projectiles require only guidance and a warhead. Due to the large amount of kinetic energy in the hypersonic projectile, damage effects could be greatly enhanced over a conventional explosive warhead.

High Risk / High Potential Research Areas. A highly network-centric fleet will be a heavy consumer of information technology and related electronic devices, advanced materials including structural (e.g., advanced composites), functional (e.g., semiconductors and superconductors) and energetic materials (e.g., explosives and propellants) and energy sources (e.g., propulsion and electricity). Two current areas of research that show promise of leap ahead breakthroughs in addressing these needs are nanotechnology and biotechnology.

- **Nanotechnology:** Nanotechnology is the ability to manipulate matter at the molecular scale to produce advanced materials and sub-micron size devices that have the potential for orders of magnitude performance over current materials and devices. Examples that could improve the fleet's capabilities in areas cited earlier include:
    - Highly efficient computer chips to increase processing densities well above that of the lithography techniques that are currently being pushed to their physical limits.
    - Structural materials 100 times stronger than conventional aerospace materials are potentially feasible by guiding the carbon deposition process to produce structural materials with carbon nanotube strength properties.
    - High power-density nanoscale electric motor-generators operating at megahertz cycles for high throughput, could greatly exceed the energy density of batteries and fuel cells.
- **Biotechnology:** This emerging technology has great potential for utility to the future fleet. The Navy is a prolific user of petroleum-based energy. Biomass represents a large potential energy resource that is currently not competitive with petroleum but may

become so as petroleum resources are depleted and biotechnology improves the efficiency of converting biomass to alcohol. Biomass is also universally available so if energy can be generated in the field, it would greatly reduce the logistics burden. Beyond alternative fuels, biotechnology has significant potential for new portable power sources; sensors for chemicals (e.g. explosives), biological agents and radiation; health monitoring; performance enhancement; combat identification; and camouflage and concealment.

5. Alternative Fleet Architecture Design

New Design Principles for Future Fleet Architectures

Planning for military forces, particularly for naval forces, has fundamentally changed. It is not just that the end of the Cold War shifted the challenge faced by our military from confronting and deterring a global military power to a series of interventions against enemies with much smaller classical military formations. That has been clear for some time now and the Department of Defense has been working to rebalance its planning accordingly. Equally significant are advances in technology (especially information technology) and successful experiments in new organizational structures that have opened up new ways of delivering military capabilities with greater speed and effect.

New ***design principles***, relevant to the Information Age and the emerging theory of ***network-centric warfare*** (***NCW***), have been identified to help guide the design of future U.S. military forces, including the U.S. Navy. These design principles, the ***new rules set***, properly applied, will put the U.S. Armed Forces on a path that ensures that they are well prepared to execute their future missions. These design principles were used to develop an ***alternative future fleet platform architecture*** for the U.S. Navy. Additionally, ***new metrics*** have been formulated by the Office of Force Transformation (OFT) to assess the competence and relevance of U.S. forces to emerging challenges. The key elements of ***the new rule set*** and ***the new metrics*** are described in this chapter. They point to the opportunity and imperative of designing the future fleet so that it rides the crest of technology trends and becomes steadily more capable relative to potential future adversaries as technology advances.

Advances in technology and innovations in organization offer better ways to design and employ military force. The most important example is the power of networked behavior. The Navy can design a fleet architecture made up of a network of many smaller units that taken together deliver a fleet with the combat power of a fleet of larger combatants while being more adaptable to the dynamic security environment. This performance is not derived from the physical network, but the co-evolution of the organization, processes, and technology in a highly interactive setting. No aspect is allowed to be held constant.

The U.S. Navy can build smaller, lower unit cost combatants without compromising on combat power because power and size have been decoupled through advances in physics that reduce the size of systems and advances in technology that increase the power of networks. This is particularly helpful against non-traditional adversaries when the U.S. needs a fast response time, consciously trading off the tension between the cost of speed and the value of time. Finally, the U.S. can increase its forces' tactical stability by recognizing the power of the collective as well as by improving the survivability of individual platforms.[1] A force comprised of elements with lower unit cost can be distributed over a larger area and achieve a network that matches the

[1] For a fuller discussion, see A.I. Kaufman, *Strategic Implications of Distributed Networked Naval Force Capability* (Washington, D.C.: Institute for Defense Analysis, 2004).

complexity of the adversary. Networked forces are particularly important in confronting enemies in a complex environment such as the littoral and provide a powerful edge in maintaining the strategic advantage the U.S. Navy has established in the ocean commons.

The remainder of this section outlines the emerging rule set, which provides a foundation for designing a powerful, responsive, and adaptable fleet. These rules include:

- ***Capabilities of a fleet are decoupled from platforms.***
- ***Power and survivability of a fleet have been decoupled from size.***
- ***Information has been substituted for mass.***
- ***Sensor proximity and persistence will drive the utility of weapons reach.***
- ***Mass customization delivers greater value than mass production.***
- ***Networked components outperform integrated systems.***

Capabilities of a Fleet are Decoupled from Platforms. Technological changes have enabled design modularity and networking, giving the Navy new flexibility in designing a fleet architecture that decouples capabilities of the fleet from the sum of the capabilities of individual platforms.

Modular ship designs allow the Navy to choose desired systems and substitute them on and off ships. These modular platforms can be reconfigured to tailor the capability to focus on the immediate operational needs. The fleet can with the same number of total hulls, respond to a broader range of challenges.

Additionally, networking allows multiple platforms, including smaller platforms, to coordinate and combine firepower and sensor capacity to deliver concentrated and precise effect. As a result, capabilities are not determined, for example, by the sum of the firepower delivered by a flotilla of combatants, but by the combined capability of the networked fleet that grows exponentially as the network expands.

A networked fleet made up of many ships that can be configured to a particular mission can adapt to changed circumstances. This “battle network modularity” is a powerful capability in an era where unanticipated challenges can emerge.

Power and Survivability Decoupled from Size. Three breakthroughs have enabled power and size to be decoupled. First, munitions can be delivered with much greater precision. Second, technological advances have reduced the size of systems and weapons required to provide a

certain effect. For example, high-energy-density weapons can multiply the explosive force of a warhead of a given size and weight. Taken together, a smaller payload can deliver the same military effects that formerly could only be produced by large platforms. An example of the effect precision munitions have had is shown in **Table 5-1** below. The trend to fewer sorties (or munitions delivered) to destroy a target allows military capability to be packaged into smaller units. Third, networking allows smaller platforms, to coordinate and combine firepower and sensor capacity to deliver concentrated and precise effect. Smaller ships, as part of a netted force, can have the power comparable to that provided by larger platforms while preserving the advantage of high complexity.

Conflict	Sorties
World War II	1000-2000
Vietnam	20-50
Desert Storm	1-2
Kosovo	More than one target per sortie

Table 5-1. Aircraft Sorties Required to Destroy a Fixed Target

Survivability can increase as size decreases. Small platforms can be designed with greater speed, maneuverability, and a smaller signature than large ships. This allows them to elude detection, tracking, and strike by an enemy rather than relying on thickness of armor for survivability. Moreover, their greater numbers makes it harder for an enemy to establish and maintain track on the total force and to determine what to attack to get the maximum payoff.

Unmanned vehicles can be designed to be even more stealthy (and can be smaller and lighter) because they do not have to provide the life support systems or protection to a sailor or pilot. Generous use of unmanned vehicles is included in the alternative future fleet architecture examples presented in this report.

Information Has Been Substituted for Mass. This metric refers to two aspects of military force: physical mass of a particular hull form, and the massing versus the dispersal of ships.

Typical battles of the 20th century required large, heavily armored ships and tanks that could withstand a frontal assault against a sizable enemy. Mass – the size and thickness (and in some cases, the doubling) of ship hulls – was essential to survivability in an era when U.S. forces had to be within visual range (and therefore enemy gun range) to locate and hit a target.

The 20th century's mass-heavy warfare follows a historical pattern between the mode of production and the mode of warfare. Napoleon created the *levée en masse* during an age of labor-intense production. In the next century, the industrial-age was in full swing when first world nations produced military forces that drew their power from large numbers of well-armored platforms. Today, in the midst of the information revolution, the United States' advantage has shifted to technology and information-enabled military forces.

Because the Information Age has shifted warfare dynamics, ships no longer need to mass for defense. Historically, “the decision to mass or disperse depended not on offensive, but rather on defensive considerations.”[2] With new technologies, the Navy can trade off hull mass for speed, networking, and interdependence. Coupled with new tactics for littoral combat, the Navy can achieve overmatching complexity against an adversary. The result is a force that loses nothing in offensive capability, since dispersed forces can create massed firepower, and one that relies upon its fast and fluid nature to confound an enemy’s surveillance tracking, targeting, and strike capacity.

Technology has allowed U.S. forces to engage the enemy more precisely thereby requiring much less mass for the same military effect. For example, in Vietnam it took 20-50 sorties to destroy a target versus just 1-2 sorties in Desert Storm (see **Table 5-1**). Global positioning system (GPS) guidance enables remotely launched weapons to hit targets with precision largely independent of standoff distance.

Finally, rather than needing a big chassis to carry a heavy and bulky magazine of munitions, sensors and other systems necessary for a particular mission, networking permits a comparable system and payload to be distributed over many smaller platforms. Therefore, several ships with smaller mass with a higher payload fraction, provided they are networked, can together deliver capabilities comparable to a much larger ship, with the added benefits of increased adaptability, speed, and complexity.

Sensor Proximity and Persistence Will Drive the Utility of Weapons Reach. The capability of our sensors will be increasingly important to future operations. Advances in guidance systems, including use of GPS technology, have decoupled precision from distance. Aircraft and ships can strike small targets from hundreds (even thousands) of miles away with the same precision that only line of sight weapons could achieve till recently. This gives U.S. forces a strike capability that reaches as far as foreseeable conflicts require. The key is to know where the enemy is located.

Operations in Afghanistan and Iraq reveal nascent elements of this important warfare shift. Special operations personnel on the ground acted as sensors for air-delivered precision weapons by spotting enemy forces, determining their exact locations using the global positioning system (GPS), and passing target coordinates directly to strike aircraft.

Enemies in the future can be expected to attempt hiding strategies, blending forces into their background settings, and moving quickly and stealthily. Sensors, or better yet sensor networks, that can penetrate and navigate these difficult environments will permit the full exploitation of our weapons reach in coping with irregular challenges in the future. Persistent sensing and proximate sensing of the environment will go a long way to extending sensor reach out to where full use can be made of weapons reach.

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[2] Wayne P. Hughes, *Fleet Tactics and Coastal Combat* (Annapolis, MD: Naval Institute Press, 2000) p. 287.

First, advances in lighter-weight sensors, lighter-weight structural materials, and more efficient engines is extending the time an aerial sensor can spend over a target area from hours to days. Moreover, the new generation of unmanned aerial vehicles now in advanced research incorporate advanced stealth technologies that will make them more survivable while sensing a hostile environment.

Second, sensors can be distributed over a broad area and networked together to ensure that there are sensors proximate to all areas of interest. Sensors with very low power requirements and advances in managing a sensor network have made this option feasible.

Mass Customization Delivers Greater Value than Mass Production. Traditionally, defense procurement followed the logic of mass production – producing large quantities of the same thing to lower the unit cost. This method of production for the Navy resulted in many nearly identical ships produced over the course of decades. An example is the production of the Arleigh Burke Class guided missile destroyer (DDG), which started in 1985 and continues today, two decades later.

In the relative stasis of the Cold War, long production runs that delivered identical ships or ships with the evolutionary improvements over decades was tolerable. However, today we are in a dynamic period of change and increasing complexity. The Navy needs to be able to modify the capabilities of ships significantly on an as-needed basis to respond to emerging changes in the security environment and attendant changes in mission requirements. This makes a production system of mass customization far more valuable.

The aim of mass customization is to produce goods and services that meet the specific needs of a sizable number of clients at costs roughly corresponding to those of standard mass produced goods. Advances in technology, particularly the development of programmable, computer-based machines, modules that conform to standard interfaces, and networked systems, have made mass customization possible.

An example of mass customization is a ship hull with common interfaces designed to allow the substitution of major systems – weapons suites, sensors or unmanned vehicles. The Littoral Combat Ship (LCS) moves in this direction. The LCS is envisioned to introduce a new level of design modularity, including configuration modularity (varied deployment of standardized modules, such as weapons suites, electronics, and the ship's technical equipment), mission modularity (containerized weapons and equipment packages) and battle network modularity (the end flexibility from multiple module ships within a network).[3] In the private sector, an example of mass customization is Dell™ computers, which start with basic models but allow customers to modify features, such as the size of the hard drive or inclusion of a CD writer at production costs only modestly higher than single design mass production.

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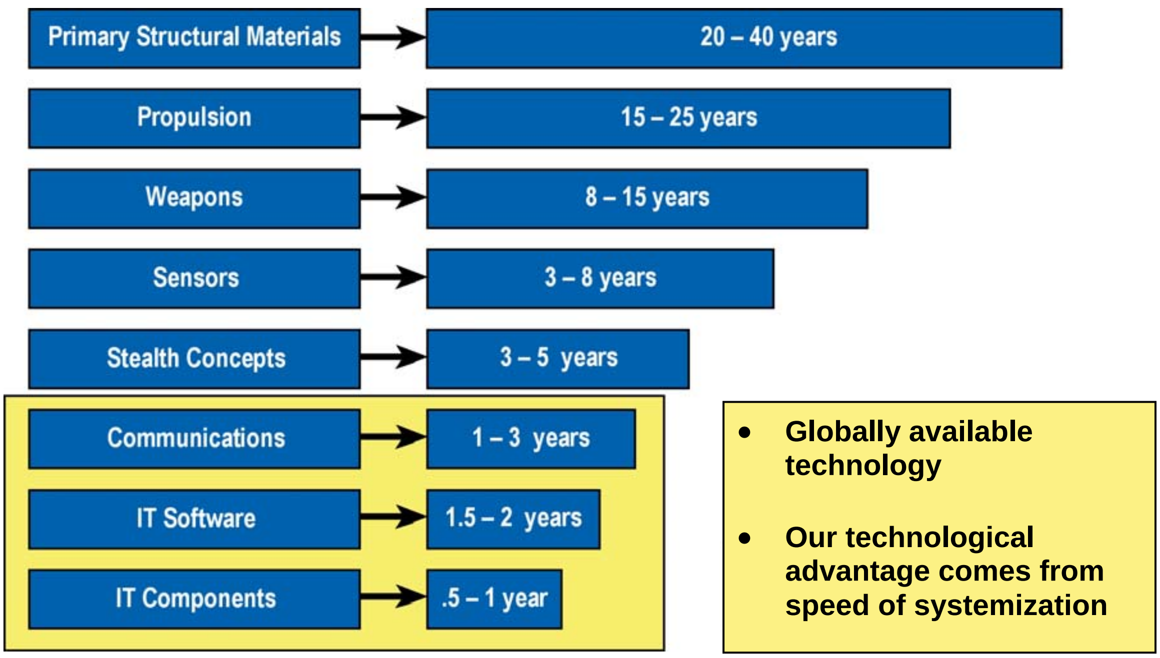
[3] Robert O. Work, "Naval Transformation and the Littoral Combat Ship," *Center for Strategic and Budgetary Assessments*, February 2004. Accessed through http://www.csbaonline.org on 10/7/2004.

As learning curve phenomenon moves to the design phase, mass customization preserves options and flexibility in the design and production of the naval fleet of the future. By contrast, mass production of highly integrated platforms limits our options.

Figure 5-1 shows the cycle times of advances in key technologies. Mass customization coupled with modular design enables a fleet architecture to incorporate new capabilities on a cycle time that more closely matches advances. The example fleet architectures presented in this report depend on a high degree of modularity to allow a steady upgrade in capabilities on a cycle time that matches advances in communications, IT software, and IT components rather than materials and propulsion.



Source: Naval Research Advisory Committee

Figure 5-1. Technology Trends and Cycles

Networked Components Outperform Integrated Systems. Over the last two decades, the United States has intervened in many smaller conflicts: Kuwait, Bosnia, Kosovo, Somalia, Haiti, and now Afghanistan and Iraq. The large Navy ships with tightly integrated systems, built and designed primarily for large scale fleet-on-fleet operations against the Soviet fleet, are generally considered too expensive to risk losing in small operations like these. Each ship houses such concentrated, powerful capabilities that its loss would be significant. These concerns, combined with technological progress in networking, point to an alternative way to structure the naval fleet architecture. More detailed information about the power of networking is provided in **Appendix B.**

Integrated system ships, such as the DD(X), combine firepower, sensor, command, stealth, and communications together – creating a ship that can operate autonomously. Networks, on the other hand, allow systems to be separated and placed on smaller, specialized platforms without losing the ability to create precise, coordinated effects. Networked components, because they are

specialized, can be smaller and therefore faster and more maneuverable. This in itself complicates the enemy's detection, tracking, and targeting problem. Moreover, if any one platform is destroyed, the effect is not catastrophic. The network can adjust and reconstitute. Finally, the fleet structure is more flexible and therefore more complex – a key trait for success in an environment of dynamic non-contiguous battlefields.

The New Metrics

Competency Metrics. The Office of Force Transformation (OFT), Office of the Secretary of Defense (OSD) has developed a set of "competency metrics" to set a standard for assessing the value of future military forces. The metrics build on changes the information revolution has wrought and on the judgment that future conflicts will be more diverse, dynamic and non-traditional than they have been in the past. Taken together, they underline the power of information-based activities and show the powerful coupling of the speed of information and the speed of physical movement.

- **Access—**the ability to use military assets, both information and physical, at the best points of effect in hard-to-reach locations even when denial strategies are employed by the enemy;

- **Speed—**minimization of response time from deliberate operational (or strategic) maneuver to stunning tactical swiftness;

- **Distribution—**the extent to which firepower, sensors, and other systems are spread over a diverse and geographically dispersed set of assets/platforms;

- **Sensing—**the ability to provide information with accuracy, timeliness, and relevance, and especially to locate and track fleeting targets;

- **Mobility—**the ease and promptness by which military assets can be shifted from one physical location to another; and

- **Networking—**the extent to which military assets are connected together through information technology that assures shared awareness and information access.

These metrics capture the key platform and force characteristics to be emphasized in investment, design, and procurement processes to ensure that the future fleet architecture has the capabilities needed for the emerging era, dominated by a dynamic security environment. Implicit in the set as a whole is the payoff in ensuring that the speed of physical movement is in balance with the speed of information. Otherwise the non-contiguous battlespace will be frustrated.

Relevancy Metrics to Drive Future Force Planning. Globalization and the information age have accelerated rates of change and have increased complexity and unpredictability in the international system. That said, our inability to predict the future in detail does not mean we know nothing about it. For example, great power war has, for now, been taken off the table. The

United States has become so proficient in executing classical state-versus-state conflict that the battlefield has been shifting to smaller and smaller aggregations of combatants.

The challenge for the immediate future is frequent contingencies of a wide variety across a wide geographic arc against an assortment of adversaries, none of which can compare to U.S. naval or overall military strength. At the same time, the eventual rise of a maritime contender with peer capabilities in its immediate region remains possible and has to be monitored.

Existing processes for planning and developing new forces still largely reflect Cold War paradigms. For that environment, gradual, incremental improvement in capabilities sufficed. The Office of Force Transformation has developed new metrics that drive fleet design to outcomes of flexibility, adaptability, and innovation, both throughout the investment and development processes and in the final architecture design. These metrics, which safeguard relevancy of the force in the diverse set of possible futures are:

- The creation and preservation of options
- High transaction rates
- High learning rates
- Overmatching complexity at scale

These become the prime metrics in both force building and force operations and are discussed in greater detail below.

Creation and Preservation of Options. In uncertain times, when flexibility is of greatest value, organizations, including the Navy, survive and prosper through the development and preservation of options. The creation and preservation of options dramatically complicates a potential enemy's decision processes, broadens the base of our choices, reduces risk and defers regret. Practices that narrow options early should be abandoned.

In investment and platform design, the Pentagon would be well served to end the practice of picking winners and losers early, in the name of efficiency. Hidden assumptions, such as 40 years as the optimal life span of ships, must be rethought. For an entirely new type of ship, it is difficult to see the basis on which we might down-select to a single "best" ship design -- a decision that destroys intellectual innovation and limits the potential of firms to compete in the future. Instead, the Pentagon needs to extend the competition of ideas farther into processes, thereby increasing the institutional learning that would come from testing and analyzing multiple ship options.

Exploration through experimentation or wargaming with new technologies or concepts is also important, as it can lead to new fleet designs, new tactics or new operational capabilities that deliver options to the commander.

High Transaction Rates. The transaction rate increases as the number of actors and the number of interactions with the competition and the environment increases. The quality and quantity of those interactions over time drives up learning and success. The speed that information is collected, communicated, digested, and acted upon by U.S. forces powerfully accelerates the transaction rate. The ability to compete based on cycle time is a powerful advantage that suppresses the time required to create or exercise an option. It is at the heart of the concept of seizing the initiative in either force building or force operations.

High Learning Rates. The achievement of high learning rates is important for preserving relevance in the information age and is closely coupled with high transaction rates. Achievement of high learning rates is also correlated with distributed operations and experimentation.

In the current acquisition system, some technologies and platforms take great lengths of time to move from the research and development stage to actual usage on the battlefield. The longer an idea takes to reach the battlefield as hardware, the shorter will be its period of usefulness. The sooner the Navy experiments with new ideas, the more quickly it can integrate successes. This is particularly important because the United States faces an age where rapid learning is a key to competitive advantage.

Some of our adversaries are adapting and evolving at the speed of business while much of our military is operating at the speed of doctrine. If the U.S. is to take advantage of what the new age offers, fast institutional learning is critical—both in force building and in operations. To create higher learning quality at higher learning rates, the Navy is best served by pursuing a rich mix of approaches to similar problems. This can include steps to foster innovative thinking, emphasize diverse experiences as an essential qualification for leaders, ensure that experiences in the field are communicated widely and absorbed, and encourage experimentation in operational units as a regular part of peacetime operations.

Overmatching Complexity at Scale. Complexity is the number, variety, and interaction patterns of entities within a system. Complexity in the physical sense is easy to understand—we like enemies to mass because a consolidated element has less complexity and presents a high value target vulnerable to our combined arms strike capability. Under the same principle, a guerilla force can frustrate a traditional military force because, though it has low mass and technical sophistication, it has very high complexity.

The goal of our forces is to present overmatching complexity to the enemy to include overmatching complexity ***at scale***. When the enemy manifests as individuals or small groups that attack using guerrilla tactics, we need to have similarly small, mobile and flexible units to fight back.

Sea Base Concept

The Navy's Sea Base concept is a key organizing principle of the planned future fleet. The Navy describes it as the foundation from which offensive and defensive fires are to be projected. As enemy access to weapons of mass destruction grows, and the availability of overseas bases declines, the Navy finds it compelling both militarily and politically to reduce the vulnerability of U.S. forces through expanded use of secure, mobile, networked sea bases. Sea Base capabilities include enhanced afloat positioning of joint assets; offensive and defensive power projection; command and control; integrated joint logistics; and accelerated deployment and employment timelines. Netted and dispersed sea bases will consist of numerous platforms, including nuclear-powered aircraft carriers, multi-mission destroyers, submarines with Special Forces, and maritime pre-positioned ships.

A key focus of this report is that the sea base is the sea, not the things on it. The fleet architecture was designed to take advantage of the dynamics of operational maneuver that exploit not only the land commons but the sea commons. Operational maneuver that includes the sea surface expands greatly the maneuver space available to our forces thereby providing our forces with more options and complicating the enemy's ability to maintain surveillance of our forces.

In utilizing the sea as a base, it is important to maintain connectivity through networking, not to mass at the same physical location. The latter would simply recreate offshore the vulnerabilities of a forward garrison on land to conventional barrage attack or to attack from weapons of mass destruction, albeit at a somewhat greater stand-off distance.

Full use of the potential of the sea as a base involves the inclusion of joint and allied forces. While it includes amphibious assault, it is much more than that. Modernizing old amphibious ships and maritime prepositioning ships is only a small part of the overall concept of sea basing. The fleet's ability to operate anywhere, including along the littoral breaks down the land-sea boundary, expanding our maneuver space, and providing multiple means of bringing military force to bear on the enemy. The architecture of the sea base is open so it can scale to the dimensions appropriate to the mission.

6. Examples of Fleet Platform Architectures

Background

Three powerful imperatives that drive the design of the ***alternative future fleet platform architectures*** presented in this chapter are described in **Chapters 2**, **3**, and **4**:

- **Strategic Context:** The security environment has become increasingly dynamic and complex. The Navy must be ready to take part in joint intervention operations and crisis response while maintaining the strategic advantage it has established in the global ocean commons.

- **Budgetary Challenges:** The programmed future fleet architecture was designed on the assumption that funding for naval procurement in general and for shipbuilding in particular would grow rapidly. Such funding growth cannot be counted upon.

- **Technology Opportunities:** Advances in technology, especially information technology, provide the Navy with the opportunity to design a fleet of many lower unit cost platforms that can disperse widely, gather and share large amounts of information, and bring precise force to bear promptly where needed.

The new ***design principles*** for the development of the future fleet platform architectures, including the ***new rules set*** and the ***new metrics***, are addressed in **Chapter 5**, along with the important concept of ***sea basing***, and the ***prioritized naval capabilities*** required by the fleet in the future that were developed during two workshops at the Naval War College last year.

Taking into consideration the three imperatives, the new design principles for the fleet, the sea base concept, and the prioritized naval capabilities required in the future, three examples of ***alternative fleet platform architectures*** (labeled ***A***, ***B***, and ***C***) were developed. They are explicitly designed to exploit the power of networking that delivers a capability that exceeds the sum of its component parts. Moreover, they take advantage of technology trends leading to greater capabilities in smaller packages.

The example alternative architectures follow a much different trajectory than the programmed fleet architectures. This is not to say that the Navy has been standing still. During the nineties, there was a deliberate shift in the focus of the Navy program from ocean dominance (fleet-on-fleet) to the capability to strike targets ashore. Moreover, the programmed future fleet architecture continues this trend and, if it could be funded, would result in a significantly modernized fleet.

Nature of the Future Fleet

The alternative fleet architectures utilize ship designs of lower unit cost. The ships make extensive use of modularity to provide the ability to adapt quickly to changes in operational or strategic requirements. Accent is put on hull designs that are fast and maneuverable with a standardized interface to allow a variety of combat modules to be exchanged rapidly.

The architectures take advantage of networking, speed, numbers, and dispersal to deliver future fleets that are highly capable, adaptable, and relevant to the spectrum of challenges that lie on the horizon. With these attributes, especially networking, future fleets are empowered with relevance, present complexity to the adversary, preserve an increased number of options, and generate increased transaction rates and higher learning rates. The architectures include a generous component of small ships and a strategy of modularity is adopted rather than integration of many systems within a single hull. The "speed" of the fleet is not only the speed of craft motion but speed in swapping out modules on the spot to ensure relevance and to present complexity and uncertainty with which an enemy must contend. Such module exchange speeds are achieved by carrying modules on larger ships that support the smaller ones forward. The large deck ships in the alternative architectures can be configured either to carry aviation or large numbers of vertical launch systems (VLS) and advanced guns (eventually electro-magnetic launch guns and perhaps high-energy lasers) that deliver large volumes of firepower. This contributes to the speed of response and as necessary to the defense of the fleet formations.

The alternative fleet architectures presented here are designed to take advantage of extensive networking among spatially distributed forces. Simply put, they emphasize greater numbers of ships that draw their power from their ability to execute network-centric warfare (NCW). See **Appendix B** for a discussion of the power of networking and the emerging theory of NCW.

The programmed Navy with its emphasis on large multi-mission integrated ships can also realize advantages from networking. Its ForceNet program includes aggressive plans to introduce as much of this as possible. Nonetheless, the high unit cost of programmed combatants coupled with reduced shipbuilding budgets will limit the size of the fleet and therefore the extent to which it can exploit the advantages of networking.

Programmed Fleet

The Navy organizes its combat forces around several formations: the carrier strike group (CSG), the expeditionary strike group (ESG), and the surface strike group (SSG). They form the focus of this chapter. Nuclear-powered attack submarines (SSNs) that are part of these formations are also addressed. SSNs that are not part of these formations and support ships like the Combat Logistics Force (CLF) are not addressed in the same detail.

There are 12 CSGs, 12 ESGs, and 9 SSGs in the programmed fleet architecture, with a total of 210 surface and 24 subsurface combatants. These include the following ship numbers and types:

- 12 nuclear powered aircraft carriers (CVNs)
- 60 littoral combat ships (LCSs)
- 12 fast combat support ships (T-AOEs)
- 12 amphibious assault ships (LHDs)
- 12 amphibious transport docks (LPDs)
- 12 dock landing ships (LSDs)
- 78 experimental guided missile cruisers (CGXs)
- 12 experimental destroyers (DDXs)
- 24 nuclear-powered attack submarines (SSNs)
- 282 unmanned vehicles (UVs)
- Also included are the aviation units for these ships.

The Navy has yet to settle on a specific program goal for UVs. The estimate of 282 given here is based upon the following information. The programmed fleet has 60 LCSs, and, with current designs, there is room on each for a maximum of three unmanned vehicles. The specific type of UV could vary, being unmanned underwater vehicles (UUVs), unmanned surface vehicles (USVs), or unmanned aerial vehicles (UAVs). The Navy also has plans to develop UAVs for deployment with carrier air wings, with roughly eight for each of the twelve carriers. In addition, a remote minehunting system consisting of one UUV could be deployed on 6 of the Navy's current DDG class destroyers; the same load is posited for 6 of the DDXs. The total number of UVs in the programmed fleet could shrink or grow depending on new advances in technology and changing programmatic priorities.

Alternative Fleet Architectures

The examples of future fleet architectures are just that: examples. These alternatives were chosen for analytical purposes and executability, not because any particular component is necessary for the viability of the example architecture. The examples demonstrate that it is possible to construct fleet architectures made up of ships that are now being built, successful prototypes, or designs within the bounds of demonstrated technology. The future fleet architecture could be assembled from ships that, individually, are different. Hybrid architectures combining elements of the proposed alternatives with each other or with the programmed fleet may also be envisioned. The key is that an alternative conform to the architecture design principles described in the previous chapter.

Alternative fleet platform architectures were developed with an eye to developing the required naval capabilities as simply as possible but in such a way that poses maximum complexity to an enemy. The basic functional formations planned for the programmed fleet were maintained in designing the three alternative fleet platform architectures for analytic purposes. Existing hull

designs were used and configured in well-established ways to constitute alternative fleet architectures.

The small-hulled ships are designed to accept modules that can be swapped out to configure the ships with the capabilities relevant to the mission at hand. A smaller number of large ships provide high volume firepower, aviation, troop spaces, module support at sea, and logistical transport as needed.

The large ships have flat tops that accommodate systems and sensors for combat as well as cargo space to carry modules for the small combatants, unmanned vehicles, and space for maintenance and housekeeping functions. Existing concept ship designs for the alternative hull forms were used. The large ships in alternatives A and B are built by using a hull taken from the Maritime Prepositioning Force Future (MPF [F]) Analysis of Alternatives (AoA)[4]. The hull type used in this study is 57,000 tons full load displacement and 260 meters in length. For comparison, an LHD has a displacement of 40 thousand tons and is about the same length.

Numbers of manned aircraft are the same in the alternative fleets and the programmed fleet. Very Short Take-Off and Landing (VSTOL) Joint Strike Fighter (JSF) aircraft were used on the alternative smaller carriers, although advances in electromagnetic aircraft launching systems (EMALS) combined with modifications in the JSF will make it possible over time to operate a modified JSF off these decks very close to the Conventional Take and Off and Landing (CTOL) configuration. This latter version would have only a marginal penalty in range-payload capability. Alternatives to the SSNs in formations were diesel Air Independent Propulsion (AIP) submarines and unmanned undersea vehicles (UUVs). The AIP submarines were substituted for Virginia class SSNs on a cost basis of roughly four to one. The AIP submarines would be brought to theater by the large surface ships. These submarines could be nuclear-powered if they are designed and built based upon a competitive, cost suppressing business model.

Alternative fleet platform architectures were constructed at an equal cost to the programmed fleet architecture in terms of procurement costs and 30 years of operating and support costs. To achieve equal cost for a numerically larger surface fleet, the number of hull types was minimized. The largest ships, those over 20,000 tons in the programmed Navy, are individually more survivable, once hit, than the smaller craft in the alternatives, but the alternative small combatants are designed to be less targetable because of their smaller signature, higher speed, and greater maneuverability. The alternative forces are elegant in their simplicity. While individually (by platform), they are less technically complicated than the programmed fleet, collectively, these alternative fleet architectures present greater complexity to the enemy, thereby complicating his planning.

Descriptions of the component ships used to assemble the alternative fleet architecture are presented in the tables that follow.

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[4] CNA Report D9814, *Maritime Prepositioning Force Future (MPF [F]) Analysis of Alternatives (AoA)*, April 2004

Aviation Ship (X-AVS)

- Used in aviation strike groups of Alternatives A and B
- Full load displacement 57,000 tons
- Concept design from Maritime Prepositioning Force (Future) MPF (F) Assessment of Alternatives (AoA) Study
- Supports 30 VSTOL (or modified CTOL) JSF, 6 MV-22, and 15 unmanned aerial vehicles (UAVs) in CSG
- Stowage and working space for unmanned underwater vehicles (UUVs), unmanned surface vehicles (USVs), and modules for small surface combatants (SSC-1000s in Alternative A)
- Cranes for changing modules
- Integrated Landing Platform (ILP) for UUV and USV operations
- Speed 30-40 knots
- Crew: 50 civilian for routine ship operations and 500 Navy for warfighting functions

Small Aviation Ship (X-CRS)

- Used in aviation strike group of Alternative C instead of X-AVS
- Full load displacement 13,500 tons
- Concept design from Naval Postgraduate School Total Ship Systems Engineering Team 2001
- Hull is surface effect ship (SES)/catamaran
- Used to support 8 VSTOL JSF, 2 MV-22, and 8 UAVs in CSG
- Speed 50-60 knots

Weapons Ship (X-WPS)

- Used in aviation, expeditionary, and surface strike groups of Alternatives A, B, and C
- Full load displacement 57,000 tons
- 360 vertical launch system (VLS) cells
- 4 trainable rocket launchers (TRLs)
- Stowage and working space for UUVs, USVs, and modules for small surface combatants (SSC-1000s in Alternative A)
- Support for limited numbers of VSC-100 combatants (Alternative B SSG) or aircraft or UAVs
- Integrated landing platform (ILP) and cranes
- Speed 30-40 knots
- Crew: 50 civilian for routine ship operations and 500 Navy for warfighting functions

Support Ship (X-SPT)

- Used in aviation and expeditionary strike groups of Alternatives B and C
- Used to support very small combatant craft (VSC-100)
- Full load displacement 57,000 tons
- Carries the VSC-100 craft and their modules
- Stowage and working space for VSC-100 craft and modules
- Cranes to lift VSC-100 on and off
- Speed 30-40 knots
- Crew: 50 civilian for routine ship operations and 500 Navy to support VSC-100

Amphibious Operations Support Ship (T-AKX)

- Used in expeditionary strike groups of Alternatives A, B, and C
- Full load displacement 57,000 tons
- Supports 30 CH-46 equivalents or 6 VSTOL (or modified CTOL) JSF, 18 MV-22, and 3 Gyrocopter Heavy Lift Helos
- Cargo space for square and cube
- Working space for load configuration
- Space for UVs and modules for SSC-1000s
- Speed 30-40 knots
- Crew: 50 civilian for routine ship operations and 500 Navy for warfighting functions

Small Surface Combatant (SSC-1000)

- Used in aviation, expeditionary, and surface strike groups of Alternatives A
- Small, fast, modular surface combatant
- Full Load Displacement: 1,000 tons
- Speed: 40-50 knots; Crew: 22
- Fixed systems
  - Multifunction radar
  - Surface to Air Missiles
  - Close-In Weapon Systems
  - Towed Array Sonar
  - Hull-Mounted Active Sonar
  - CEC, IFF, EW, Thermal Imaging system
- Accommodate all fixed systems and one module
- Modules:
  - ASW: Variable depth sonar, torpedoes, fire control system
  - Helicopter support for SH-60 type: Weapons, sensors, fuel
  - Strike: 9-cell launcher, fire control system, 3 UAVs (targeting)
  - Mine Warfare: Remote mine hunting systems, acoustic counter measure system, mine neutralization system
  - SOF: 3 rigid-hull inflatable boats
  - USV: 3 unmanned surface vehicles
  - SUW: Surface-to-surface missiles
  - AAW: 12-cell launcher and missiles
- Modules: carried in the large ships in the formations
- Half Modules: Half of a set of modules bought for each SSC-1000 due to number of SSC-1000s and module availability in each formation

Very Small Surface Combatant (VSC-100)
◆ Used in the aviation, expeditionary, and surface strike groups of Alternatives B and C ◆ Small, fast, modular surface combatant craft ◆ Carried to theater by large support ship (X-SPT) ◆ Payload capacity increased as less fuel carried ◆ Full Load Displacement: 100 tons ◆ Speed: 60 knots; Crew: 3 ◆ Limited capacity for fixed systems, carries one module at a time ◆ Operated as a unit or in flights of two or more craft ◆ Modules: – ASW-1: Variable depth sonar – ASW-2: Towed array, torpedoes, fire control system – Strike-1: 6-cell launcher, fire control system – Strike-2: 3 UAVs (for targeting) – Mine Warfare: 1 UUV, acoustic MCM system, mine neutralization system – SOF: 2 rigid-hull inflatable boats – USV: 2 unmanned surface vehicles – SUW-1: 8 Surface-to-surface missiles – SUW-2: Close-In Weapon System – AAW: Launcher, missiles, multifunction radar – UUV: 12 medium UUVs – Sensors: small sensors for acoustic detection ◆ Half of a set of modules bought for each VSC-100

Table 6-1. Characteristics of Alternative Proposed Ship Types

The modular small combatants provide agility, flexibility, and speed. Two examples of small surface combatants (SSCs) are used in designing the examples of alternative fleet architectures presented in this chapter. As shown in **Table 6-2**, one is the SSC-1000, displacing 1,000 tons, that self-deploys to theater. The other is a very small combatant (VSC), the VSC-100, a 100-ton craft that is carried to theater by the support ship (X-SPT). Actual designs for these small ships were developed by the Naval Sea Systems Command (NAVSEA) and were used as the basis for cost and effectiveness calculations.

SSC-1000	VSC-100
Length: 70 meters	Length: 40 meters
Payload Fraction: 15%	Payload Fraction: 30%

Table 6-2. Alternative Small Surface Combatants

Three alternatives (labeled A, B, and C) of future fleet platform architectures are presented. All three contain a richer complement of smaller ships than the programmed fleet architecture. The

alternatives progress along a spectrum of greater numbers and a larger complement of unmanned systems.

Alternative A. Three large hull ship types are used in this alternative: an aircraft carrier (designated X-AVS in subsequent discussions) that is smaller than programmed CVNs, a weapons ship (X-WPS), and an amphibious operations support ship (T-AKX).

Each of the 12 aviation strike groups (ASGs) in Alternative A, as shown in **Table 6-3,** consists of:

- Two 57,000 ton displacement aviation ships (X-AVSs) that *together* support 60 VSTOL (or modified CTOL) Joint Strike Fighters (JSF), 12 MV-22 tilt rotor (TR) aircraft, and several unmanned aerial vehicles (UAVs);
- One weapons-heavy ship (X-WPS) with 360 vertical launch systems (VLS) and trainable rocket launchers (TRL);
- 16 SSC-1000, a 1,000 tons displacement ship, that can self-deploy to the theater and can be configured with a variety of combat modules as the mission demands;
- Four AIP diesel submarines at costs comparable to that of one SSN (Virginia Class); and
- One fast combat support ship (T-AOE) combat logistics force (CLF) station ship for fuel and stores.

For size comparison, the X-AVS aviation ship is similar in size to the new aircraft carrier planned by the United Kingdom, which is expected to support about 50 VSTOL aircraft. The existing French light aircraft carrier, the *Charles de Gaulle*, supports 35 to 40 aircraft at a full load displacement of 41,000 tons, some 70% of that of the X-AVS design.

Programmed Carrier Strike Group (CSG)		Alternative A Aviation Strike Group (ASG)	
Platform Type	12 Formations Number Vessels in each Formation	Platform Type	12 Formations Number Vessels in each Formation
CVN	1	X-AVS	2
Aircraft	60 JSF (CV), 12 MV-22 and 8 UAV	Aircraft	60 VSTOL (or modified CTOL) JSF, 12 MV-22 and 9 UAV
CGX	3	X-WPS	1
LCS	2	SSC-1000	16
UV	6	UV	3 USV and 18 UUV on each X-AVS and X-WPS
SSN	1	AIP Submarine	4
T-AOE	1	T-AOE	1

Table 6-3. Comparison of the Programmed CSG and the Alternative A ASG

The large ships also carry back up modules for the SSC-1000 ships.

Each of the 12 Expeditionary Strike Groups (ESGs) in Alternative A, as shown in **Table 6-4**, consists of:

- Two large hull T-AKX ships, supporting a Marine Expeditionary Unit (MEU) carrying six VSTOL (or modified CTOL) JSF, 18 MV-22, and three gyrocopter heavy lift aircraft,
- One weapons ship (X-WPS), and
- 15 SSC-1000 small combatants.

Programmed Expeditionary Strike Group (ESG)		Alternative A Expeditionary Strike Group (ESG)	
Platform Type	12 Formations Number Vessels in each Formation	Platform Type	12 Formations Number Vessels in each Formation
LHD, LPD and LSD	1 each	T-AKX (MPF (F))	2
Aircraft	6 JSF (VSTOL) and 24 MV-22	Aircraft	6 VSTOL (or modified CTOL) JSF, 18 MV-22, 3 Gyrocopter Heavy Lift Helos and 3 UAV
CGX	2	X-WPS	1
DDX	1		
UV	9-10	UV	3 USV and 18 UUV on X-WPS
LCS	3	SSC-1000	15
SSN	1		

Table 6-4. The Programmed ESG and the Alternative A ESG

Each of the nine Surface Strike Groups (SSGs) for Alternative A, as shown in **Table 6-5**, consists of:

- One weapons ship (X-WPS), and
- Five SSC-1000 ships.

Programmed Surface Strike Group (SSG)		Alternative A Surface Strike Group (SSG)	
Platform Type	9 Formations Number Vessels in each Formation	Platform Type	9 Formations Number Vessels in each Formation
CGX	3	X-WPS	1
		UV	3 UAV, 3 USV and 18 UUV on X-WPS
		SSC-1000	5

Table 6-5. Comparison of the Programmed SSG and the Alternative A SSG

In addition, each aviation (X-AVS) and each weapons (X-WPS) ship carries a package of aerial, surface, and undersea unmanned vehicles (UAV, USV, UUV). Each package consists of three UAVs, three USVs, and 18 UUVs. The UUV package consists of two large, four medium and 12 small UUVs.

Alternative B. The aviation (X-AVS) and weapons (X-WPS) ships are used in the same manner in this alternative, but a very small combatant (VSC)-100 replaces the SSC-1000. The VSC-100 displaces 100 tons at full load. The support ship, X-SPT, transports it and its modules to the zone of operations. It offloads them configured with the module relevant to the operations at hand. The VSC-100 combatants then return to the support ship, are on-loaded via a crane system for general housekeeping functions and to exchange modules as required. Since the VSC-100 does not need a transoceanic range, fuel can be traded for modular payload bringing its payload fraction up to 30 percent.

The Alternative B ASG (shown in **Table 6-6**) consists of:

- Two aviation ships (X-AVS),
- One weapons ship (X-WPS),
- One support ship (X-SPT),
- 24 VSC-100 small combatants,
- Four AIP diesel submarines, and
- One fast combat support ship (T-AOE).

Programmed Carrier Strike Group (CSG)		Alternative B Aviation Strike Group (ASG)	
Platform Type	12 Formations Number Vessels in each Formation	Platform Type	12 Formations Number Vessels in each Formation
CVN	1	X-AVS	2
Aircraft	60 JSF (CV), 12 MV-22 and 8 UAV	Aircraft	60 VSTOL (or modified CTOL) JSF, 12 MV-22 and 9 UAV
CGX	3	X-WPS	1
LCS	2	VSC-100	24
		X-SPT	1
UV	6	UV	3 USV and 18 UUV on each X-AVS and X-WPS
SSN	1	AIP Submarine	4
T-AOE	1	T-AOE	1

Table 6-6. The Programmed CSG and the Alternative B ASG

The corresponding ESG, as shown in **Table 6-7**, consists of:

- Two amphibious assault (TAK-X),
- One weapons ship (X-WPS),
- One support ship (X-SPT), and
- 23 VSC-100 small combatants.

Programmed Expeditionary Strike Group (ESG)		Alternative B Expeditionary Strike Group (ESG)	
Platform Type	12 Formations Number Vessels in each Formation	Platform Type	12 Formations Number Vessels in each Formation
LHD, LPD and LSD	1 each	T-AKX (MPF(F))	2
Aircraft	6 VSTOL JSF and 24 MV-22	Aircraft	6 JSF VSTOL (or modified CTOL) JSF,18 MV-22, 3 MC-X3 and 3 UAV
CGX	2	X-WPS	1
DDX	1		
UV	9-10	UV	3 USV and 18 UUV on X-WPS
		X-SPT	1
LCS	3	VSC-100	23
SSN	1		

Table 6-7. The Programmed ESG and the Alternative B ESG

The corresponding SSG for Alternative B, as shown in **Table 6-8**, consists of:

- One weapons ship (X-WPS) and
- Five VSC-100 small combatants.

Programmed Surface Strike Group (SSG)		Alternative B Surface Strike Group (SSG)	
Platform Type	9 Formations Number Vessels in each Formation	Platform Type	9 Formations Number Vessels in each Formation
CGX	3	X-WPS	1
		UV	3 UAV, 3 USV and 18 UUV on X-WPS
		VSC-100	5

Table 6-8. Comparison of the Programmed SSG and the Alternative B SSG

The weapons ship (X-WPS) in this group would be configured with a crane and cradles to support the VSC-100s.

Each aviation (X-AVS) and weapons ship (X-WPS) in Alternative B carries the package of unmanned vehicles described in Alternative A: 3 UAVs, 3 USVs, and 18 UUVs apiece.

Alternative C. This alternative has the smallest and most numerous ships. Very small aviation support ships, designated as Corsairs or X-CRS based on a concept design developed at the Naval Postgraduate School, replace the aviation ships (X-AVS). The replacement based on cost and capability, is four X-CRS ships for one X-AVS ship. Each of the 12 ASGs of Alternative C, shown in **Table 6-9**, consists of eight X-CRS ships. This is the only change to Alternative B. The ESG and SSG in Alternative C are the same as in Alternative B. The set of unmanned vehicles is spread over the four small aviation ships (X-CRSs). The X-CRS's displacement is 13,500 tons and supports eight JSF, two MV-22, and eight UAVs. Its maximum speed is 60 knots.

Programmed Carrier Strike Group (CSG)		Alternative C Aviation Strike Group (ASG)	
Platform Type	12 Formations Number Vessels in each Formation	Platform Type	12 Formations Number Vessels in each Formation
CVN	1	X-CRS	8
UV	6	UV	3 USV and 18 UUV on X-WPS
Aircraft	60 JSF (CV), 12 MV-22 and 8 UAV	Aircraft	64 VSTOL JSF,16 MV-22 and 67 UAV
CGX	3	X-WPS	1
LCS	2	VSC-100	24
		X-SPT	1
SSN	1	AIP	4
T-AOE	1	T-AOE	1

Table 6-9. Comparison of the Programmed CSG and the Alternative C ASG

The numbers of ships and submarines in each alternative are compared to the planned fleet architecture by formation in **Table 6-10**.

Formation Type	Number Formations in Fleet	Number Surface and Subsurface Combatants			
		Programmed	Alternative Fleets		
			A	B	C
Carrier Strike Group	12	96	288	396	468
Expeditionary Strike Group	12	120	216	324	324
Surface Strike Group	9	27	54	54	54
Total Number Combatants		243	558	774	846
Total Number UVs		282	1,368	1.368	1,560

Table 6-10. Programmed and Alternative Fleet Sizes

The alternatives are designed to significantly increase the number of combatants in the fleet over the programmed number. The results show the numbers of combatants increasing from 243 in the planned architecture to 558 in Alternative A, 774 in Alternative B, and 846 in Alternative C.

Evaluating Fleet Capabilities

As explained in **Chapter 3**, it appears unlikely for resources to be available to build the full fleet architecture shown in **Table 6-10**. A key advantage of the alternatives over the programmed fleet is that they scale better. The alternatives include large numbers of lower unit cost ships so that in times of tight shipbuilding budgets the fleet can maintain a critical numerical size. When more resources *do* become available, the Navy can take advantage of the opportunity by building these ships more rapidly. A key to success for any of the fleet architectures is that at all times, the Navy supports experimenting with ship designs that target greater speed, maneuverability, higher payload fraction, and seaworthiness.

Capability areas. The fleet needs the capabilities shown in **Table 6-11**. These capabilities are aggregations of the detailed list of capabilities supplied by the Office of the Chief of Naval Operations, N-70. They were reviewed in the two decision support exercises held at the Naval War College and an assessment was made of how critical each was likely to be in meeting future challenges.

First, the fleet must be able to develop and communicate knowledge about forces and the military situation. As computers continue to grow more powerful and the capacity for exchanging large amounts of information expands these activities will increasingly be executable by directly exchanging data between battlefield elements in real time through data networks.

◆ Develop and Communicate Knowledge of Forces and Situation
◆ Control Operational Domain
◆ Bring Joint Forces to Bear where Needed Promptly
◆ Fight from the Sea
◆ Sustain Joint Forces
◆ Deny Enemy Ability to Hold Homeland at Risk

Table 6-11. Capability Areas

Second, a fleet must be able to control the area from within which it conducts its operations. Specifically, it must be able to survive threats posed by undersea weapons, enemy surface ships, aircraft, and missile attacks launched either from the opposing fleet from shore installations.

Third, a fleet must be able to deploy its forces to optimize its ability to arrive in the right place at the right time. Fundamental to this capability is the size of geographic area that the fleet can access. Given potential access, a fleet must be quick to move in order to arrive quickly, and it

must be highly maneuverable in order to get into the most advantageous tactical position. The speed and maneuverability of individual ships will also enhance the fleet's survivability if it comes under attack.

Next, a fleet must be ready to fight once it is properly deployed. If the operation is aimed at an opposing fleet, it must be able to engage and destroy that fleet's assets; if the operation is aimed at supporting a land battle, it must be able to attack and destroy both fixed and mobile land targets, and it must be able to insert special operation forces where they are needed.

Since the duration of the war is often uncontrollable, a fleet must also be able to sustain itself and, if necessary sustain the expeditionary forces operating ashore. This capability essentially requires that the fleet have the resilience to always fight another day if the circumstances demand.

Finally a fleet must be able to contribute to the emerging capability of denying an enemy the ability to hold the U.S. homeland at risk. This capability might require that the fleet participate in missile defense, in monitoring suspect shipping bound for the U.S., in port defense, and in sea control along our shores.

U.S. Security Policy and Enemy Behavior. All the capabilities described above are important, though which capability is most important to the nation depends upon the character of our national security policy and upon the nature of the enemy we encounter.

If our national leadership chooses to continue a policy of intervening to stabilize critical regions or to head off emerging threats to our security, we can expect to face enemies that employ asymmetric tactics. On the other hand, if our leadership emphasizes maintaining our strategic advantage in the ocean commons, the fleet will have to prepare to contend with an adversary that challenges us directly and possibly symmetrically in the ocean commons.

Some capabilities are more critical in one circumstance than the other. Agility, access, and power projection are the most important capabilities if the fleet is to support an interventionist policy. Control of relevant areas – large areas of the world's oceans or portions of homeland periphery -- is the most important capability if the fleet is to support a strategic advantage policy.

If the enemy turns out to behave in an asymmetric manner, networking of a larger number of fleet assets is, as will be subsequently shown in this chapter, the best way to achieve the desired capabilities. If the enemy is symmetric, the best way to attain the desired capability is to increase the survivability of fleet assets, a goal that could be achieved either by improving the defensive capability of programmed platforms or by networking a larger and more widely dispersed number of fleet assets.

Quantifying Fleet Capabilities. A capability analysis was performed that focuses on the two most challenging cases. First the imperative to intervene as needed and cope with an enemy that could be expected to resist using asymmetric tactics was analyzed. Next, the need to maintain the

strategic advantage the Navy has established in the ocean commons in the face of a competent enemy challenging us symmetrically in its region was analyzed. Quantification of a fleet's capabilities is routinely provided by campaign analyses that embed the fleet within specified scenarios and then calculate the likely outcomes as a function of inputs describing the enemy, the fleet, and the system that composes them both. Properly done, they can yield valuable detailed information on fleet performance. That said, campaign analyses require detailed assumptions and the details can obscure and overwhelm the broad capability characteristics sought.

A different tack has been adopted in this study. The authors leap beyond the current philosophy for designing the nation's fleet and seek a vantage point from which to examine the fundamental assumptions that underpin that philosophy, and then to explore alternatives. To this end, models that identify and measure parametrically the critical factors that drive capability are employed. The details of the future may be uncertain, but the foregoing analysis provides a rather clear picture of the capabilities the fleet will need to cope. Particular attention is paid to the imperatives of getting on the right side of technology trends so that over time, the fleet architecture's capabilities grow relative to the challenges posed by the competition. This approach yields greater insights than campaign analysis when the exact nature of future challenges is uncertain and it avoids a point solution dependent on details. Such a solution is likely to prove too brittle when details emerge that are different from those assumed.

Models aimed at identifying the critical factors that drive capability need not be detailed campaign models, with many specific input parameters. Indeed it is better to avoid this since it is impossible to determine with precision the inputs that will reflect future challenges with fidelity. The main thrust of this analysis is to discern how best to ensure that critical capabilities are resident in the fleet. The models used are intentionally transparent and simple to explore how key factors we identify affect fleet capability, as opposed to describing in detail performance in a particular scenario. The capability models used in the study to compare future fleet capabilities provided by the alternative architectures are described in **Appendix C**. More detail concerning these models and concepts may be found in the *Comparison of Potential Future Fleet Architectures*, a report prepared by the Institute for Defense Analyses.[5]

Analysis of Alternatives. Next the question of fleet capability in a dynamic future is addressed by using these models for the two critical circumstances identified above. Begin with the case in which U.S. security policy continues to have a strong interventionist component. Under these circumstances, the needed capabilities are: agility, access and control of operational domains, and the ability to fight from the sea (power projection). The Navy is mainly focused upon supporting the land battle from the sea and it must therefore tailor its operations to the dynamics of that battle. Agility, measured by the fleet's ability to quickly get to the right location, is thus important. In a similar fashion, since supporting land operations requires that the Navy be positioned within striking distance of land targets, a fleet participating in an interventionist action would have to gain access to the enemy's littorals against the anti-access forces that the enemy deploys there. Finally, since the whole reason for using the fleet in an interventionist war is to

[5] IDA Paper P-3980, *Comparison of Potential Future Fleet Architectures*, Institute for Defense Analyses, January 2005.

affect the battle on land, the fleet must be able to deliver a sizable power projection punch once it has accessed the littoral.

- **Interventionist Policy / Asymmetric Enemy:** Enemy action is more likely to be aimed at exploiting the vulnerabilities of the fleet than at confronting it head on. Consequently, the enemy would be driven to attempt to strike and flee rather than confront our forces openly. Similarly, the fleet's ability to remove the various anti-access assets the enemy would surely deploy against it could be significantly reduced by enemy tactics designed to hide from surveillance when and where those assets were deployed. Finally, enemy targets could choose to operate in an environment in which the surrounding objects provide them with an ability to break track before we can launch weapons against them. Therefore, the most important critical factor to all the relevant capabilities is the enemy's ability to elude detection.

  The enemy's ability to hide can be controlled by networking sensors on many dispersed platforms. Networking, made increasingly stronger by rapidly developing information technologies, promises to deliver two different kinds of benefits. First, by rapidly sharing information, networking enhances the effective performance capability of each platform. It is the capability of the network, not the capability of each individual element, which ultimately matters in a networked force. For instance, by using information made available to the network by all ships, any individual ship in the network could launch weapons at targets outside of its own detection range. Second, by allowing free information flow between military personnel, the network could enable through spontaneous self-organization a more cohesive behavior out of which focused, relevant action can emerge.

  A networked fleet consisting of many platforms offers therefore the promise of being not only more capable but also more relevant to fighting an asymmetric enemy in an interventionist setting. By inculcating cohesive behavior, networking effectively denies an asymmetric enemy the powerful lever of elusion and deception. Indeed, a networked force can operate faster, have significantly more tactical options, and generate a more fluid picture of its instantaneous posture and subsequent intentions. This new flexibility and complex array of possibilities would make it difficult for any enemy to figure out exactly what action would generate deception; it may not be able to figure out what will happen next, to set up an appropriate deception plan, and to adapt rapidly enough to changes confronting it.

  In the analysis, the programmed fleet was compared parametrically with its alternatives quantitatively as well as qualitatively. Comparisons are made between the fleets for three capabilities: Control Operational Domain, Promptly Bring Forces to Bear, and Fight from the Sea.[6]

[6] Ibid. The in-depth analysis used to arrive at the comparisons between the programmed fleet and the Alternative Fleet Architectures shown in Tables 6-1, 6-2, and 6-3 is described in the aforementioned IDA report.

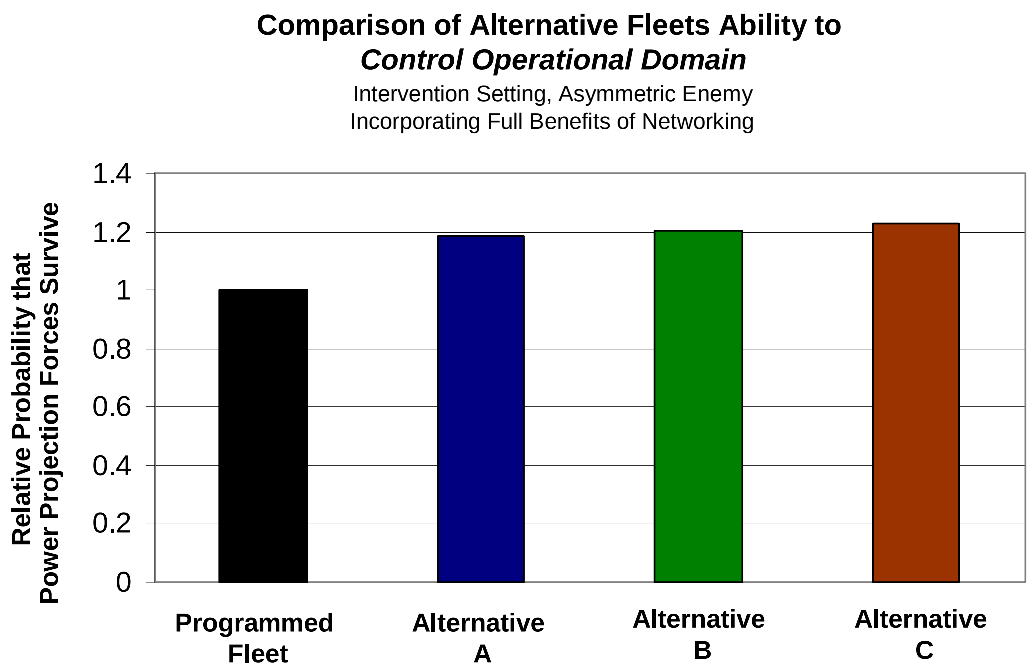

Figure 6-1. Comparing Programmed and Fleet Alternatives' Ability to Control Operational Domain, Incorporating the Full Benefits of Networking

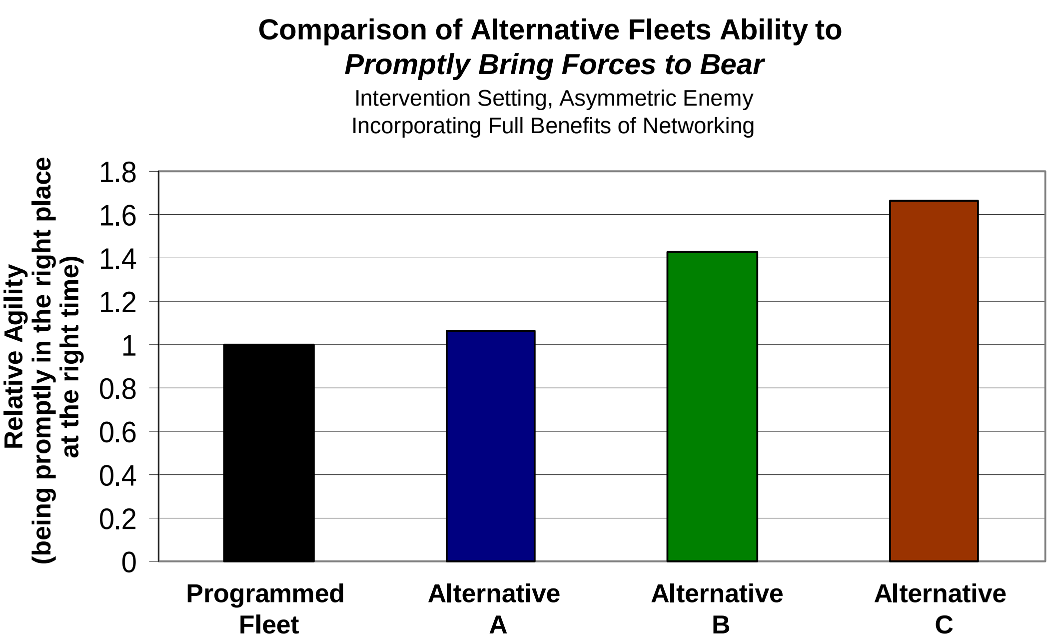

Figure 6-2. Comparing Programmed and Fleet Alternatives' Ability to Promptly Bring Forces to Bear, Incorporating the Full Benefits of Networking

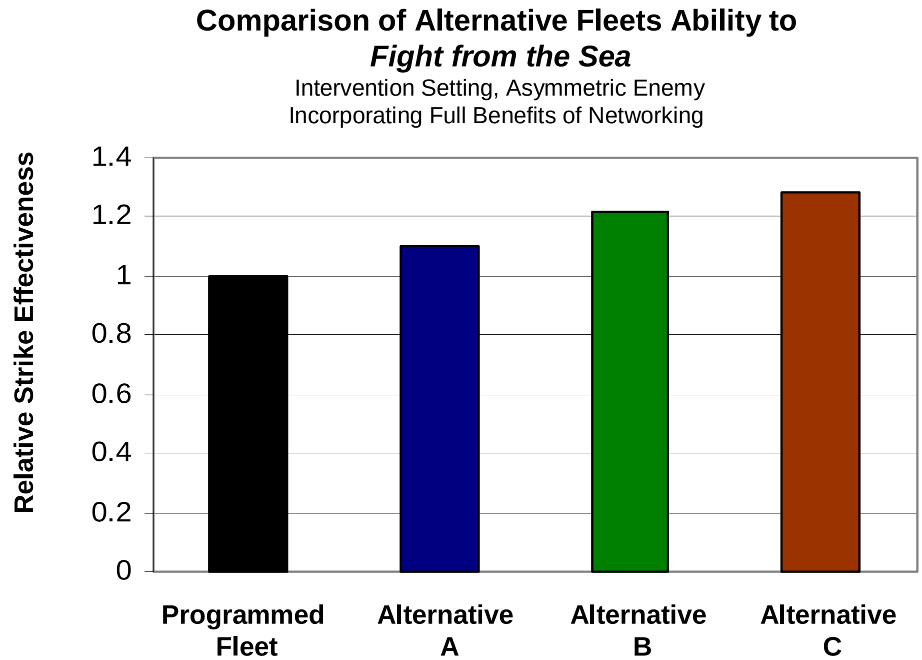

Figure 6-3. Comparing Programmed and Fleet Alternatives' Ability to Fight from the Sea, Incorporating the Full Benefits of Networking

- **Strategic Advantage Policy / Symmetric Enemy:** The next case considered is a policy that seeks to maintain strategic advantage in the global commons against a symmetric enemy determined to deny it access. The largest ships in the programmed fleet (greater than 20,000 tons) might survive an enemy hit and remain operational. Smaller ships would likely be out of action when hit. That said, the alternative architectures have different advantages. Their dispersion, numbers, speed, agility, and small signature hamper the enemy's ability to target, track, and then hit them. The key degrees of freedom are platform speed and the operational flexibility that would flow from networking. If the enemy attacked with surface or air launched missiles, numbers would help since networking provides a large fleet with the capability to confuse the enemy surface picture enough to make our alternative fleets harder to hit than the programmed one.

  The capabilities of the programmed fleet and its alternatives to control the operational domain were compared in the case in which the U.S. is pursuing a policy of strategic advantage against a symmetric enemy. These capabilities are analyzed in a similar manner as described earlier. Not modeled here is the stress put on the ability of the enemy's ISR capability to keep track of a greater number of faster, more maneuverable ships with lower signatures, which is an advantage a network of small, fast, numerous platforms would have.

  With the increased power provided by networking, the fleet alternatives can be expected to better deny the enemy's ability to read the battlefield accurately, making it harder for him to locate and track the smaller, faster, more agile ships comprising the alternatives. As shown in **Figure 6-3**, we find that, similar to the intervention / asymmetric enemy

scenario, these benefits greatly improve with the alternatives as compared to the programmed fleet.

Survivability Considerations. The analyses shown in **Chapter 4** did not address the potential differences in survivability of the surface craft. Does this consideration alter the images developed to this point?

Figure 6-4 compares the strike effectiveness of the programmed fleet and the alternatives in the interventionist policy setting against an asymmetric enemy. Losses to the fleet are included this time, namely 50 ships lost. The approach does not model how these ships might be lost but is offered to show the consequences of losses. A fixed number of losses is typically associated with a fixed number of enemy weapons launches or tracking systems. An example might result from losses to a mine field or losses to a barrage of a fixed number of ballistic missiles at the approaching fleet before the fleet can respond with a counter strike on the launchers.

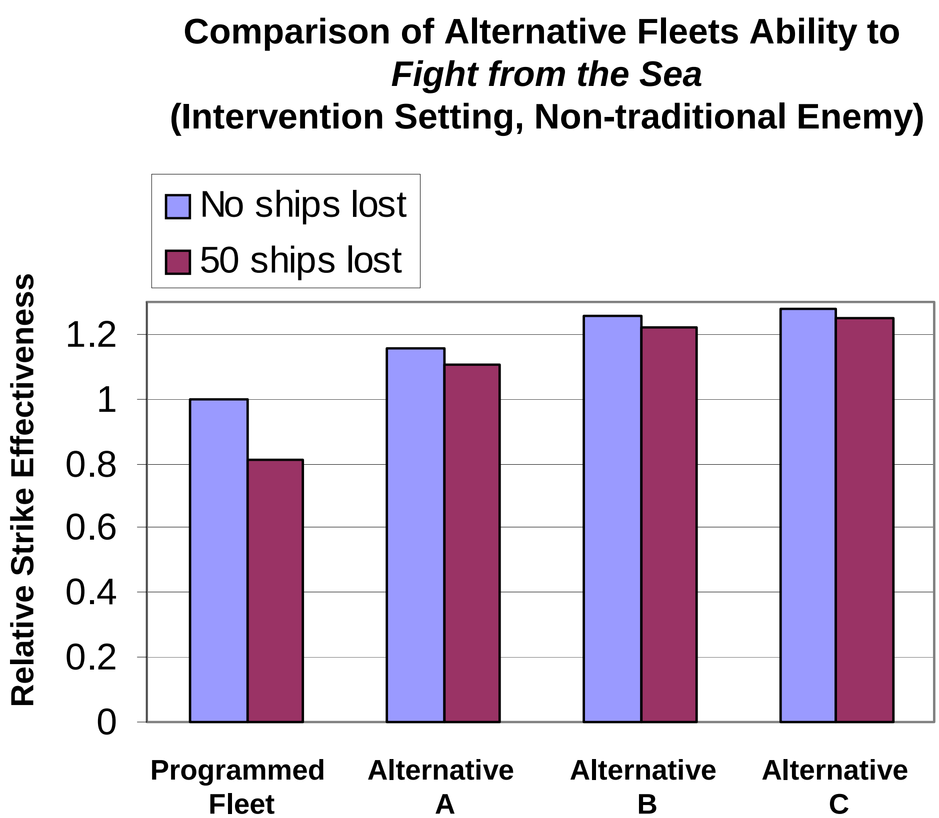

Figure 6-4. Comparing Programmed and Fleet Alternatives Ability to Fight from the Sea, Including Ship Losses in the Alternatives

The alternative fleets, even if they suffer this level of loss, maintain a greater capability than the programmed fleet.

Observations. Alternative fleet formations consisting of small fast and relatively inexpensive craft combining knowledge and attaining flexibility through networking appear superior to the programmed fleet for non-traditional warfare in a variety of settings. This is due to increasing the complexity the enemy faces and increasing U.S. fleet options that in turn reduce enemy options. The speed and complexity of the alternative fleets can provide them with the capability to complicate and possibly defeat the attempts of non-traditional adversaries to elude surveillance. The enemy could have difficulty determining what to expect and how to defeat them all. The superior speed and more numerous participants than in the programmed fleet provide a stronger intelligence base and more numerous platforms from which to conduct strikes and interceptions. This appears to be true even if the smaller craft are *individually* somewhat less capable and less able to sustain a hit than the larger ships in the programmed fleet.

If these circumstances are not achieved, and the enemy can continue to elude and deceive, the programmed fleet often is as good as the alternatives, sometimes even better. It is not necessarily better in cases in which individual ship survivability dominates, a perhaps counterintuitive result until we realize that *fleet* survivability not *individual ship* survivability is what dominates.

An area in which programmed fleets might have an advantage would be when the long loiter time or deep reach of CTOL aircraft on programmed big-deck CVNs is needed. That said, there need be no great sacrifice. With airborne tanking, the VSTOL aircraft in the alternatives could meet the deep strike and long loiter demands. Also, as mentioned earlier, a combination of advances in EMALS and modifications to the JSF will make it possible to launch the JSF with only a marginal range-payload capability penalty. Moreover, trends in technology are providing *unmanned* aircraft greater capability, including greater loiter time and sensor capability.

Implementation and Risk

If managed properly, the Navy can implement a new fleet architecture in a way that minimizes risk and maximizes the potential benefits of the example alternatives. Five principles are key to guiding the implementation of a new architecture: begin immediately, develop options, suppress unit cost, target technology insertion, and shorten building cycle time.

A shift of the nature described in this report will take time. The sooner the Navy begins to develop and explore alternatives, the sooner it will have options to choose from. Building smaller ships with plug-in combat modules has two advantages that facilitate implementation. First, this makes it possible for the Navy to develop and build ships more quickly. Further, it permits technology insertion throughout the life of the ship. **Figure 5-1** on page 52 of the previous chapter indicates technology cycle times. Information technologies in particular cycle rapidly. The ability to insert the rapidly advancing information technologies onto the *modules* means the ship does not have to stand down during the upgrade. More frequent technology insertion is thus feasible, putting the fleet in a position to ride the crest of the information technology wave.

The shipbuilding industrial base would also need to start to retool to build different types of ships more rapidly. Smaller shipyards, which presently do little or no work for the Navy could

compete to build the smaller ships, thereby broadening the capabilities base of ship design and construction available to the Navy. The change to smaller, lower unit cost ships would also open up overseas markets. With more shipyards able to build the ships and potential for a broader overall market, the U.S. shipbuilding industry would have the chance to expand its competence, innovation and relevance. Taken together this would sharpen the industry's ability to compete and provide alternatives to a ship procurement system that is beset by laws and regulations that frustrate, even pervert, market forces.

Risk would have to be managed carefully during the transition. The longevity of most of the ships in the current fleet provides an effective, if expensive, hedge. The ships presently in the fleet will need maintenance and overhaul and this will preserve for many years the technical base to keep open the option of building the types of ships envisioned in the current program. As the Navy's leadership becomes confident in the capabilities of the new fleet architecture, it can retire the legacy ships early, declare the costs to be sunk, capture the operations and maintenance savings and move aggressively to an alternative fleet architecture.

7. Conclusion

The foregoing analysis has highlighted two major imperatives that call for change in designing the U.S. Navy's future fleet platform architecture.

First, the U.S. Navy has to adapt to the changed security environment that requires it to increase its relevance to the irregular and catastrophic challenges that have emerged. At the same time, it must maintain the strategic advantage it has established in the global commons (ocean, air, space, and cyber space), ensuring that no adversary can deny the fleet the freedom to operate wherever it needs to.

Second, the resources on which the Navy was counting when it designed its future fleet architecture and formulated its long-range shipbuilding plan are not materializing and this situation is unlikely to improve in the years ahead. This development, coupled with the fact that most of the Navy's shipbuilding budget is programmed for high unit cost ships, signals a trend in the direction of an even smaller Navy that will fall short of serving the full range of national security requirements.

The ***alternative fleet architecture design*** presented in **Chapter 5** of this report provides further details on how to "find the way." The key characteristic of the three examples of alternative future fleet platform architectures presented in **Chapter 6** is that they are composed primarily of ***lower unit cost ships***. This design principle yields a fleet with a greater number of ships. It also puts the future fleet platform architecture on the right side of trends in technology. First, advances in technology, especially in precision guidance and terminal weapons effects, allow our steadily increasing strike capability to be packaged onto smaller platforms. Second, advances in information technologies open up the power of networking to the fleet. Through ***networking***, the fleet's ability to develop ***shared battlespace awareness*** and to strike responsively is amplified well beyond the sum of the naval platforms' individual capabilities.

A second important characteristic of the alternative fleet platform architectures is ***modularity*** to give the fleet operational agility. By designing ship hulls with common system interfaces, different combat modules can be swapped on and off ships. This allows the fleet to adapt rapidly to a dynamic operational environment. Moreover, it permits the Navy to incorporate advances in technology into the fleet more quickly and at less expense. Planned upgrades for DDG-51 destroyers will take each ship out of service for over a year.[7] With modular platforms, upgrades can be done on the modules themselves so the Navy does not need to pull a ship off line for extended overhaul.

Smaller, lower unit cost ships can also be made faster, more maneuverable, and present a lower signature to enemy sensors. This allows them better to elude detection or to break track once detected. Taken together with the power of networking and the adaptability provided by modularity, a fleet architecture designed with these principles presents an enemy with a far more complex challenge than at present.

[7] Christopher P. Cavas, "USN Lays out DDG Upgrade Plan," *Defense News* 25 July 2005, 48.

A fleet designed with these characteristics would place great stress on an adversary's surveillance tracking and targeting system; complicate his decision making; make it more difficult for his forces to elude detection; and allow the isolation and over-matching of enemy units.

Finally, the ***alternative fleet architecture design*** described above will enable the future fleet to scale well in either direction, as required by the evolving national strategy, the Navy's operational requirements in support of that strategy, and unpredictable budgetary restraints. When resources for shipbuilding grow, the Navy can take advantage of the opportunity and quickly expand the numbers of ships it builds. When resources decline, the program can be slowed more gradually than a program of large, highly integrated, high unit cost ships to ease the shock to the fleet.

The longstanding logic of force building falls short of the challenge for the future. It embodies elements that risk the Navy's "losing the way." The dangers include:

- **Choosing a narrow or irrelevant competitive space.** The Navy will be called upon to participate in joint intervention operations while needing to preserve its strategic advantage in the ocean commons. Focusing on one mission to the detriment of the other is a choice the Navy needn't make and would narrow the fleet's capabilities base.

- **Trying to shrink the Navy into greatness.** Focusing primarily on accommodating a shrinking budget by reducing the number of ships procured holds the risk of an ever smaller, less capable fleet.

- **Sticking with the current metrics.** The current metrics used in designing a fleet architecture view technical opportunities as risky and stifle innovation.

- **Shielding the shipbuilding industrial base from global competition** guarantees high cost, limited innovation, and long cycle times for building ships.

- **Down selecting early to one "best" design** chokes off competition among design teams prematurely. Design is the very phase in ship development where the greatest innovation takes place. Related is the danger of stifling progress in cost suppression and innovation by cutting the R&D account to "balance" the budget.

The alternative fleet architecture offers a set of opportunities for the Navy to "find the way."

- **Achieve coherence in fleet building and in operations.** A fleet architecture can be designed with a broadened capabilities base to prepare for both the continued need to intervene *and* to preserve the Navy's strategic advantage in the global commons. Risk can thereby be managed and regret (from making sub-optimal choices) delayed.

- **Build a large and more capable Navy** characterized by "the small, the fast, the many." This fleet would gain considerable power from networked behavior and its ability to sense over a broad area.

- **Competition on cost and time.** The approach to fleet architecture design described in this report emphasizes the advantages of generating and preserving options, maintaining a high transaction rate, maintaining a high learning rate, and presenting greatly increased complexity to an enemy.

- **Seize technology opportunities early.** Technology has reached maturity that allows the Navy to develop a diverse set of platforms that, with standard interfaces, allow systems modules to be swapped on and off ships. This expands the opportunity to spin-on advances in technology and to adapt the fleet architecture responsively to changing operational or strategic circumstances.

Appendix A—Determining Capabilities Required in the Future Fleet: A Decision Support Exercise

Capabilities Required in the Fleet

In the spring of 2004, two decision support workshops were held at the Naval War College at Newport, Rhode Island, the first in April and the second in May. The primary objective of these workshops was to develop a prioritized list of capabilities that the fleet will need in the future. A group of national security analysts from the military, industry, and academia with extensive experience in naval force planning and operations was assembled. Their charge was to explore how changing global conditions can inform the Navy about the capabilities it must field to meet future challenges.

The most significant results of the two decision support workshops are presented in the three short sections that follow: "Military Activities," "Prioritizing Military Activities," and "Prioritizing Fleet Capabilities." **Chapter 5** ("Alternative Fleet Architecture Design") describes the ***new rules set***, the principles guiding the design of the alternative fleet platform architectures, and the ***new metrics***, to be used in assessing the capabilities the fleet can deliver. The ***new rules set*** and the list of ***prioritized naval capabilities*** developed by the Naval War College workshops (see **Table A-2**) helped guide the development of the alternative future fleet platform architectures presented in **Chapter 6**.

Military Activities

Although we cannot predict the future in detail, this does not mean that we know nothing of it. As described in **Chapter 2** ("Strategic Context"), we have some idea of the types of security challenges the U.S. will face in the years ahead. Participants at the April 2004 decision support workshop developed a set of military activities that the U.S. Armed Forces must be capable of executing as they plan for the future. The list spans a broad spectrum of type and intensity of activities.

- **Constabulary operations:** Relatively small-scale policing actions, such as those conducted in Haiti in 2004.

- **Military support to civilian authorities:** Activities that include such things as counter-drug and counter-illegal immigration operations.

- **Counter-terrorism operations:** Operations pertaining to the global war on terrorism.

- **Counter-proliferation operations:** Efforts to retard the spread of technologies and weapons that could be used to create mass devastation.

- **Crisis response:** Activities related to manmade crises that require intervention by external forces.

- **Deter major contingency:** Prevent aggression by potential regional adversaries.

- **Deter peer/global war:** Activities aimed at deterring behavior of potential peer competitors that might lead to conflict.

- **Deter and defeat WMD use:** This is found in other activities but the consequences of nuclear war are so serious that participants felt it deserved separate consideration.

- **Extended deterrence/defense:** The ability to spread a defensive umbrella (for such things as air and missile defense) over allies, friends, and coalition partners.

- **Fight & win major contingency:** Activities involved in contingencies like Iraq.

- **Global Engagement:** Activities whose objectives are to engender good will and interoperability with allies and partners.

- **Humanitarian operations:** Activities related to natural disasters that require intervention by external forces.

- **Impose U.S. will (compellence):** Self-explanatory.

- **Collect intelligence:** Self-explanatory.

- **Enforce international agreements:** Self-explanatory.

- **Conduct limited operations against a major power:** Activities short of conflict such as those conducted during 1996 Taiwan Strait crisis.

- **Protect U.S. lives/property abroad:** Self-explanatory.

- **Conduct punitive strikes:** Retaliatory activities such as those mounted against Libya in Operation El Dorado Canyon.

- **Stabilization operations:** These activities are performed on a much larger scale than constabulary operations and involve a broader range of capabilities. The occupation activities following the overthrow of Saddam Hussein's regime in Iraq are representative.

- **Protection of the commons:** The commons include the oceans, the airways, space, and cyberspace.

- **Demonstration of capabilities:** Capability demonstrations to convince a potential adversary that his desired course of action is futile (without shots having to be fired).

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- **Homeland Defense:** Activities associated with a layered defense of the homeland. While some of the activities above apply to this area, participants believed it deserved to be considered on its own.

Prioritizing Military Activities

The participants in the second decision support workshop were first asked to assess how critical the military activities are in achieving the eight strategic objectives identified in National Defense Strategy.

- Secure the United States against direct attack;
- Ensure strategic access;
- Establish favorable security conditions;
- Increase capability of partners;
- Assure allies & friends;
- Dissuade potential adversaries;
- Deter aggression & coercion; and
- Defeat adversaries.

Based on these objectives, the participants built a prioritized list of military activities to determine which capabilities should be stressed in future naval force structure. Results are shown in **Table A-1** below. This list formed the prioritized master list that was used to determine the capabilities the fleet will need in the future.

Naval War College Workshop Two	
1	Extended deterrence / defense
2	Deter peer / global war
3	Deter major contingency
4	Fight & win a major contingency
5	Crisis response
6	Deter and defeat WMD use
7	Homeland defense
8	Global engagement
9	Counter-terrorism operations
10	Collect intelligence
11	Conduct force demonstration
12	Stabilization operations
13	Counter-proliferation operations

Table A-1. Prioritized Military Activities

Prioritizing Fleet Capabilities

The Office of the N-70 of the Navy Staff (OPNAV) provided a list of naval capabilities for the decision support workshop participants to work with. The participants assessed the relative importance of each naval capability for executing the most important military activities in the future, as established in **Table 5-2**. Specifically, they assessed the criticality of each capability for executing the most important military activities in support of strategic objectives by assessing whether it was (1) Helpful, (2) Important, (3) Critical, or (4) Could not succeed without the capability. Naturally, some activities are more important than others and the contribution a capability makes to an activity was weighted according to that activity's importance. As shown in **Table A-2**, the workshop participants produced a list of naval capabilities that took this weighting into account:

Naval War College Workshop Two	
1	Develop battlespace knowledge
2	Deploy and employ forces
3	Maintain communications and data networks
4	Generate and maintain common operational and tactical pictures
5	Maneuver forces
6	Conduct strike operations
7	Control littoral areas
8	Command naval and joint forces
9	Conduct theater air and missile defense
10	Conduct forcible entry operations
11	Protect forces
12	Conduct air supremacy operations
13	Provide strategic deterrence
14	Conduct undersea warfare
15	Pre-position joint assets afloat
16	Provide integrated logistics support
17	Conduct surface warfare
18	Provide naval fire support

Table A-2. Prioritized Naval Capabilities

The first five prioritized naval capabilities determined by the workshop participants ranked the fleet's ability to ***develop battlespace knowledge***, ***deploy and employ forces***, ***remain connected***, ***maintain shared awareness of the battlespace***, and ***maneuver forces*** as the most critical capabilities for the future fleet architecture design. These five top priority naval capabilities point to a relationship between getting and moving information and getting and moving things. Capabilities #6-11 reflect the collective judgment of the Naval War College Workshop participants that the Navy must continue to operate forward, in harm's way. The remaining capabilities contribute to two other important areas of military activity: traditional military activities (including strategic deterrence) and force sustainment.

Appendix B—The Power of Networking

Introduction. Fundamental to designing alternative future naval fleet architectures is an understanding of the new sources of power and options that will be derived from these architectures. It is not from the platforms in the architectures presented in **Chapter 6** of this report where the greatest power is derived. The U.S. military entrance into and understanding of the Information Age provides the stepping-stone for creating a network-centric force, one that is defined by these architectures. This network-centric force is an outgrowth of the transition to the Information Age, and is driven by a key element of the DoD transformation efforts, ***network-centric warfare*** (***NCW***). Regarded as the emerging theory of war for the Information Age, NCW provides a unique approach to the conduct of warfare. Both the Services and the Joint community recognize its importance as the central organizing principle for their force transformation efforts and therefore, they are implementing NCW using the following tenets[8] as their guide.

- A robustly networked force improves information sharing.
- Information sharing enhances the quality of information and shared situational awareness.
- Shared situational awareness enables collaboration and synchronization, and enhances sustainability and speed of command.
- Taken together, these dramatically increase mission effectiveness.

NCW is helping to create and maintain a decisive warfighting advantage, which in essence leverages the power of the network and information. The Department of Defense understands this well, as each Transformation Roadmap, to include the Naval Transformation Roadmap[9], describes the importance of NCW initiatives now under development, many of which have been tested under fire in the Middle East. However, NCW is not just about the networks (which will be discussed later in this section), but it is first of all about human behavior. Thus, when examining the power of NCW, human behavior in a networked environment is the critical indicator in determining the degree to which it is being implemented and exploited.

As a key part of the emerging way of war, NCW represents a powerful set of warfighting concepts and associated military capabilities that allow warfighters to take advantage of all available information and to bring to bear all assets in a timely and flexible manner. The movement is toward a naval force that is capable of achieving U.S. strategic and operational objectives more quickly through the employment of agile, more rapidly deployable forces. To do this, naval forces must be robustly networked, organized to best exploit the network, and mentally prepared to operate in a networked environment. Fully implementing the concepts and

[8] These four basic tenets of NCW were initially set forth in *Network-Centric Warfare: Department of Defense Report to Congress*, 27 July 2001.
[9] *Naval Transformation Roadmap 2004*, Department of the Navy

capabilities associated with NCW will make the future naval force capable of gaining and maintaining decision superiority, influencing or rapidly altering initial conditions, and conducting network-centric operations to execute the missions of the 21st century.

What is Network-Centric Warfare? NCW, at the highest level, is the military's response to the Information Age. It is how military forces behave, perform, and organize themselves when they are networked. Therefore, while "the network" is a noun that represents technology as an enabler to the force, "to network" is a verb that brings to focus the actions and behavior of an organization in exploiting the power of the network.

What is the value of a networked force, and specifically a networked naval force? The commercial world set the stage in the 1990s by leveraging the power of the network in ways never before imagined. Those that were successful basically reinvented themselves, creating organizations more agile and responsive than their competitors to any change that occurred in the market place by not only putting into place the critical elements of the network, but creating a cultural change that maximized the potential of the network. Much like industry, the U.S. military must create an environment that is more favorable to our forces and less favorable to our adversaries. The power of the network is a key element in creating this favorable environment. The governing principles for a network-centric force, which constitute the new rules of warfare for the information age, provide a good framework for identifying the capabilities needed in any future networked naval force. These are:

- **Fight First for Information Superiority:** Generate and exploit high-quality shared awareness through better timeliness, accuracy, and relevance of information.
    - Increase an enemy's information needs and reduce his ability to access information.
    - Assure our own information access through well-networked and interoperable forces.

- **High-Quality Shared Awareness:** Routinely translate information and knowledge into the requisite level of common understanding and situational awareness across the spectrum of participants in joint operations.
    - Build a collaborative network of networks, populated and refreshed with quality intelligence and non-intelligence data, both raw and processed, to enable forces to build a shared awareness relevant to their needs.
    - Information users must also become information suppliers, responsible for posting information before use.
    - High-quality shared awareness requires secure and assured networks and information that can be defended.

- **Dynamic Self-Synchronization:** Increase the freedom of low-level forces to operate nearly autonomously and to re-task themselves through exploitation of shared awareness and the commander's intent:
    - Increase the value of subordinate initiative to produce a meaningful increase in operational tempo and responsiveness.
    - Rapidly adapt when important developments occur in the battlespace, and eliminate the step function character of traditional military operations.

- **Dispersed Forces:** Move combat power from the linear battlespace to non-contiguous operations:
  - Emphasize functional control versus occupation of the battlespace and generate effective combat power at the proper time and place.
  - Increase close coupling of intelligence, operations, and logistics to achieve precise effects and gain temporal advantage with dispersed forces.

- **De-massed Forces:** Move from an approach based on geographically contiguous massing of forces to one based upon achieving effects:
  - Substitute information and effects for mass to limit the need to concentrate physical forces within a specific geographical location.
  - Increase the tempo and speed of movement throughout the battlespace to complicate an opponent's targeting problem.

- **Deep Sensor Reach:** Expand the use of deployable, distributed, and networked sensors, both distant and proximate, that detect actionable information on items of interest at operationally relevant ranges to achieve desired effects:
  - Leverage increasingly persistent intelligence, surveillance, and reconnaissance (ISR).
  - Use sensors as a maneuver element to gain and maintain information superiority.
  - Exploit sensors as a deterrent when employed visibly as a part of an overt display of intent.

- **Compressed Operations and Levels of War:** Eliminate procedural boundaries between Services and within processes so that joint operations are conducted at the lowest organizational levels possible to achieve rapid and decisive effects.
  - Increase the convergence in speed of deployment, speed of employment, and speed of sustainment.
  - Eliminate "firewalls" between processes (e.g., organize, deploy, employ, sustain), operations, intelligence, and logistics.
  - Eliminate structural boundaries to merge capabilities at the lowest possible levels (e.g., joint operations at the company/sub-squadron/task unit level).

- **Rapid Speed of Command:** Create an information advantage and convert it into a competitive advantage by creating processes and procedures otherwise impossible within prudent risk:
  - Through battlefield innovation and adaptation, compress sensor-to-decision maker-to-shooter timelines to turn information advantage into decision superiority and decisive effects.
  - Progressively lock out an adversary's options, and ultimately achieve option dominance.

- **Alter Initial Conditions at Increased Rates of Change:** Exploit the principles of high-quality shared awareness, dynamic self-synchronization, dispersed and de-massed forces, deep sensor reach, compressed operations and levels of war, and rapid speed of command to enable the joint force, across the cognitive, information, and physical domains of

warfare, to swiftly identify, adapt to, and change an opponent's operating context to our advantage.

These governing principles are joint in nature, but are as applicable to the naval force. These principles are made possible through the implementation of a robust network that is a critical piece of both a future naval fleet architecture and Joint architecture as well.

The Importance of Net-Centricity. In the past, power came from the massing of forces and the firepower they brought to bear on the enemy. More and more, power is coming from information access and speed that allows the massing of a force's effects. In general, the force is able to maximize the value of each of its platforms by linking them together. These linkages cross functional lines to include sensors, command and control systems, weapon systems, the logistics system, and intelligence systems.

The power of a network is realized when the network allows for greater collaboration and coordination in real time within the military force, the results of which are greater speed of command, greater self-synchronization, and greater precision of desired effects. The word "greater" is used with respect to the enemy's in each of these categories where an advantage is sought. The goal of networking is to merge the warfighting capabilities into a seamless force that is highly agile and capable of locking out its opponent's ability to respond to high rates of change. In other words, the enemy is unable to keep up with the speed of which our naval forces operate, thereby locking out many options it might have had otherwise. In addition, the greater use of networks can lower the transaction costs of sharing information to negligible levels. This in turn opens a flood of accurate and timely information to every level of the warfighting organization. The utility is described in Metcalf's Law that states, "the usefulness, or utility, of a network equals the square of the number of users." The equation looks like this: value = $\text{node}^2 - \text{node}$. This is saying the more nodes included in a network the greater the value of the network as a whole. In the case of a future naval force, we are speaking of all the elements that make up the force to include the ships, the airborne platforms (manned and unmanned), space-based nodes, and land-based nodes. The network that makes up these nodes and their connections permit the exploitation of the power of information by all of its parts. This influenced the change of rule sets as previously discussed.

This phenomenon was first seen in business where the **network effect** (or **network externality**) caused a <u>good</u> or <u>service</u> to have a <u>value</u> to a potential <u>customer</u> dependent on the number of customers already owning that good or using that service. This meant that the total value of a good or service that possessed a network effect was roughly <u>proportional</u> to the square of the number of customers already owning that good or using that service. One consequence of a network effect is that the <u>purchase</u> of a good by one <u>individual</u> indirectly benefits others who own the good. For example if a person purchases a <u>telephone</u> that makes other telephones more useful because one more person in the "net" can be reached. In the naval forces' case the commodity is information. The objective is to reach a "critical mass" based on the number of users of the information within the network, which is increased by adding nodes to the network. Therefore, network effects become significant after a certain number of subscribers to the information are achieved; which is called critical mass. This is done not only by increasing the

number of nodes at the operational levels, but also by pushing these connections to the lowest levels of the organization, sometimes referred to "pushing the power to the edge." At the critical mass point, the value obtained from the good or service (e.g., information) is greater than or equal to the price paid for the good or service. The price, in the case of individual military units might be a requirement to feed the network with accurate and timely information.

Once critical mass is attained all facets of the organization will change. An early example of this is the telephone. The telephone was of very limited use when minimal users were connected. It became much more useful when cities were connected. But as the world became wired, the increased utility of the phone system was phenomenal. And while critical mass would have eventually been reached using analog technology, digital technology sped the progress to achieving critical mass. Naval forces now have the opportunity to reach that same critical mass, thereby maximizing use of the network. This value comes from information-intensive interactions between a very large numbers of heterogeneous computational nodes in the network. The value increases as the information moves toward 100% relevant content, 100% accuracy, with zero time delay. To achieve this requires a net-centric operational architecture that consists of three principal elements: a high-powered information backplane (or information grid); a sensor grid; and a transaction grid. This architecture provides the ability to generate and sustain very high levels of competitive space awareness, which is translated into competitive advantage.

Building a Net-Centric Naval Force. In general, the network of the new naval fleet architecture must generate increased power by networking sensors, decision makers, and munitions-delivery platforms to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization by effectively linking knowledgeable entities in the battlespace. The network of the naval fleet will support the Navy and Marine Corps' current overarching "Seabasing" concept under which they have established three pillars: Sea Base; Sea Shield; and Sea Strike. Each of these areas contains or will contain unique NCW capabilities that are considered critical to the future naval force, implementing these capabilities through their cross-cutting program called FORCEnet. FORCEnet is the Department of the Navy's lynchpin program for implementing NCW and is defined as the operational construct and architectural framework for Naval Warfare in the Information Age. This framework "integrates the Sailors and Marines, sensors, networks, command and control, platforms and weapons into a networked, distributed combat force, scalable across the spectrum of conflict from sea to space and from sea to land. As early as the 1980s the Navy began experimenting with network-centric operations when they developed and tested the Cooperative Engagement Capability (CEC) system of systems that combined a high-performance engagement sensor grid with a high-performance engagement grid. In 1996 it reached its Initial Operational capability, and today with the Marine Corps' CEC-based Composite Tracking Network provides an effective, common network of sensors and weapons and is a important piece of the of Naval NCW capabilities. The CEC system was truly pushing information out to the edge by passing in real time the information needed by tactical weapons platforms to accurately attack targets from sensors dispersed throughout the battlespace.

Experimentation and Observation of NCW and the Power of the Network. As the CEC capability continues to grow within the Navy, so do other facets of NCW. This is evidenced by

Fleet Battle Experiments (FBEs) conducted by the Navy and Marine Corps since 1997 when the first FBE was conducted. The first fleet battle experiment FBE-Alpha linked all in-theater shooters through a single network. In each FBE, emerging Navy tactical and doctrinal concepts designed using the network–centric warfare approach were tested. In general, each FBE dealt with one of the following aspects of NCW: Information/Knowledge Superiority; Information Assurance; Networking; System Interoperability; Shared Visualization/Situational Awareness; Decision Superiority; Speed of Command; Self-Synchronization; Battlespace Management; and Sustainability, all of which are equally important when implementing network capabilities. As a result of these experiments, the network and its use have been enhanced by rapidly maturing command and control capabilities, increasing the availability and efficiency of bandwidth, finding new ways of fusing data, increasing the interoperability of naval systems riding the network and most importantly improving the means for sharing data, information and knowledge across the network.

The capabilities displayed in the FBEs and in current operations show evidence of the increased application of NCW within the fleet. To build on this experience and more closely examine the overall employment of NCW systems and practices, the Office of Force Transformation (OFT) sponsored an independent assessment of one operational fleet. This assessment took place in 2003 using U.S. Fifth Fleet's Commander Task Force (CTF-50). The commander and his staff, embarked on the *USS Carl Vinson*, led a coalition force of 59 ships in combat operations during Operation Enduring Freedom that was executing missions in the Arabian Gulf and in Afghanistan. During this time, CTF-50 adopted a number of networking and collaboration tools that were described as having a significant effect on how the task force (TF) planned and executed missions. The assessment team conducted the evaluation using the OFT's NCW Conceptual Framework, which looks at the implementation of NCW in four domains: physical; information; social; and cognitive. The importance of these domains rests in how the attributes and capabilities found in one domain interacts with the other in conducting network-centric operations. In general, the cognitive domain is in the mind of the Warfighter and is the realm of effects based operations. The physical domain is the traditional domain of warfare where force is moved through time and space, and is the easiest to measure. The Information Domain is the domain where information is created, manipulated, and shared, and where the communication of information is facilitated. Finally, the Social Domain is where humans interact, exchange information, form shared awareness and understandings, and make collaborative decisions. At the intersection of all of these domains is NCW, with each intersection representing important, dynamic areas within which concept-focused experimentation must be conducted. Some of these intersections involve: shared awareness (where cognitive and information domains intersect); compressed operations (where cognitive and physical domains intersect); and precision force (where physical and information domains intersect.)

Of specific note, CTF-50 was comprised of ships from five different U.S. fleets and six nations, most of which had never trained together before becoming part of the task force. This required that the commander's intent be equally understood by all elements of CTF-50; collaboration among task force elements was continuous; and situation awareness was consistent throughout the TF. If this was achieved, operations could be conducted in the most effective manner, which in NCW terms is self-synchronization. Two aspects were part of this assessment. The first was "what was the perceived magnitude of net value?" In other words, what was the degree users

believed that the new network technology enhanced their ability to operate? The second aspect was, “how frequently did the users expect to derive that net-value.” The key technologies cited most often in the CTF-50 case study were the collaboration tools, the prominent one being “chat rooms.” The staff highlighted “chat rooms” because of their very ad hoc nature, which they believed allowed them to operate much more effectively in a constantly changing environment. In general, the assessment based on interviews with CTF-50 staff found that they experienced an improved ability to share information, propagate and maintain situation awareness, and bring improvements to bear on operations. This accessibility to up-to-date, pertinent information 24 hours a day was considered critical to both the staff and the commanders. The information sought spanned the gamut from logistics to operations and from meteorological to intelligence. CTF-50 staff credited NCW capabilities with increasing the speed of command and making the staff more agile.

The additional time acquired through the use of these capabilities provided more time for contingency planning, and thereby decreased the necessity for the staff to react and improvise. For example, Carrier Group Three staff stated that the increased time allotted to planning options resulted in the execution of 33 of the 35 plans developed by the staff. An additional bonus from the time freed up by these capabilities was the increase in down-time available, which mitigated the effects of 24-hour operations on personnel. One additional observation dealt with the social domain. Through the increased use of collaborative tools and the network, various relationships of trust resulted. Instead of the normal face-to-face interactions, these relationships were built using e-mail, chat rooms, and less frequently video-teleconferencing. This became a rich environment for exchanging needed information and establishing knowledge-based relationships, before only possible through physical interaction. Finally, the CTF-50 commander’s commitment to using the fleet’s intranet as his central mode for gaining situational awareness resulted in a major process change within the staff. Staff briefings were reduced to a minimum and the timeliness of information available to the commander and the rest of the staff was increased. Other benefits of lesser significance included less staff time dedicated to responding to outside information requests. Those outside organizations could now access the majority of information they needed directly through the command’s website.

The Naval Environment and Supporting the Joint Force. While networking the future naval force will be critical to maximizing its own power, even greater power will be gained as it connects into the larger joint network. As mentioned with Metcalf’s Law, the power of the network is proportional to the square of the nodes within that network. Therefore, the connection of naval forces to the joint force and with outside organizations via the joint network, the Global Information Grid (GIG), will allow the power of the fleet to grow exponentially. This requires that the FORCEnet construct complies with the respective interface requirements for each of the joint C4ISR programs (e.g., Joint Tactical Radio System, Deployable Joint Command & Control, Single Integrated Air Picture, etc.) with which information can be exchanged. This construct is especially important as the naval forces focus more and more on the littoral environment where sea, land, air, and even space operations intersect and the network provides the main means for communication and collaboration. In general, the littorals are a noncontiguous battlespace, and the entry fee to operate in that space is a networked force. Finally, as interdependencies between the Services increase, so too will the importance of a robust network that permits the highest

degree of information reliability and timeliness, and facilitates requirements to be instantaneously validated and acted upon.

Benefiting from Network-Centric Warfare. The power of networked forces continues to increase as the naval force further exploits the NCW capabilities through an increased use of the network and a better understanding and acceptance by each organization of being networked. Other factors are also affecting the power of the network. These include the processing power and bandwidth availability. Two laws that accompany Metcalf's Law deal with these factors. Moore's Law, first announced in 1965, stated that the capacity of semi-conductor chips will double every 18 months while the cost remains constant. This law has remained fairly valid and has resulted in the high-powered processing used today by the military. Nielsen's Law, first announced in 1998, stated that Internet bandwidth would double every two years, a rate a little less than that of chip capacity. With an increase in bandwidth, the user is presented with the means to exploit the network even more. The GIG Bandwidth Expansion (GIG-BE) is one example at the joint level where bandwidth is being maximized by the military.

In general, the future fleet architecture should be designed to exploit the power of the network. The key factors in achieving this have been integrated into the future fleet architecture examples presented in this report:

- Maximizing the number of nodes (e.g., platforms, computer stations, etc.) that are part of the network.

- Ensuring that the naval network is interoperable with the joint network that allows for an increase in the number of nodes and therefore increases exponentially the information available to users on the network.

- Changing the organization and the processes in a way that maximizes use of the network.

- Changing the culture through leadership and training that promotes the implementation of networking and increases the user's confidence in its capabilities.

- Putting into place the tools that maximize collaboration, common situational awareness, and timeliness and reliability of information, and as a result increase the agility of the force.

While great strides are being made by the naval forces in applying the principles of NCW and the power of the network, we are nowhere near reaching the bounds of its power. Ultimately, the advantage goes to those best able to exploit its capabilities through an ability to rapidly change its organizations and doctrines and to create and assimilate technologies within a very short cycle time. The future fleet architecture presented in this report is designed to be highly networked and adaptive, able to rapidly make the required changes to maintain its competitive advantage in the future.

Appendix C—Models Used to Compare Future Fleet Capabilities Provided by the Alternative Architectures

The models and concepts described in this appendix were used to compare parametrically the capabilities of the ***alternative fleet architectures*** presented in **Chapter 6**. They are described in greater detail in the report, *Comparison of Potential Future Fleet Architectures* prepared by the Institute for Defense Analyses (IDA).[10]

The first model deals with the capability to control the operational domain in an interventionist war and determines the time-dependent probability of survival for a naval power projection force that moves into position to conduct operations in support of the land battle. Imagine that an enemy has populated the approaches to his shores with a selection of anti-access systems designed to discourage U.S. power projection forces from operating there. The systems may be underwater mines, submarines, small watercraft, missiles, or some combination. Since we are taking a general rather than a very specific view of things, we model the anti-access threat as a generic field of threat distributed, over the area of strategic interest to our forces. To confront this generic threat, U.S. naval forces will conduct equally generic "removal" operations intended to eliminate it. For that purpose, the U.S. fleet deploys generic removal and then has them operate in the area covered by the enemy field. **Figure C-1** depicts this operational arrangement.

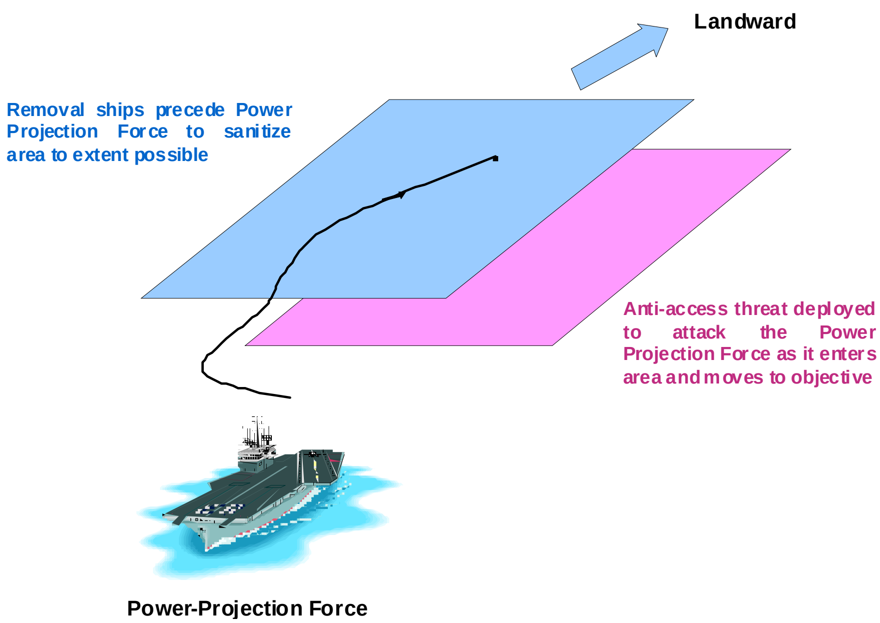

Figure C-1. Control the Operational Domain

[10] IDA Paper P-3980, *Comparison of Potential Future Fleet Architectures*, Institute for Defense Analyses, January 2005.

Consider a projection force that sails into the littoral, deploys itself through the threat field to some specified location, arrives there, and then initiates power projection operations in support of the land campaign. The probability that such a force would have survived the journey depends upon the time at which the journey begins; the later that the power projection force starts deployment, the smaller the density of anti-access threat that survived the ongoing removal operation and therefore the larger the survival probability. For a specified time at which the power projection force is called upon to act, the probability of survival depends upon the initial density of the anti-access field and the density of the removal field we are able to deploy. Under the reasonable assumption that the U.S. fleet would try to interdict deployment of anti-access assets if it knew that it was taking place, the former input parameter reflects the enemy's ability to conduct covert deployment of its anti-access forces and therefore measures the enemy's ability to deceive. The latter input parameter is directly related to the number of removal platforms the fleet employs in the given operation.

When applying this model to the strategic advantage policy case, the portion of the model comprising the movement of the power projection force into position was removed since under that policy the emphasis is on sea control and not on intervening into land operations.

The second model quantifies the capability to promptly bring forces to bear. As illustrated in **Figure C-2**, the model envisions that U.S, naval forces detect some enemy formation that they wish to engage. They therefore proceed in a direction that their intelligence and surveillance systems tell them they should follow. Inaccuracies in the intelligence and surveillance information lead to errors both in their estimate of the location and in their estimate of the direction of advance of the enemy. The attempted engagement will be successful if the actual enemy location at the time at which the intercept was to have occurred is found to be within an acceptable strike radius from U.S. forces; this acceptable strike area is represented by a dotted circular area in the figure.

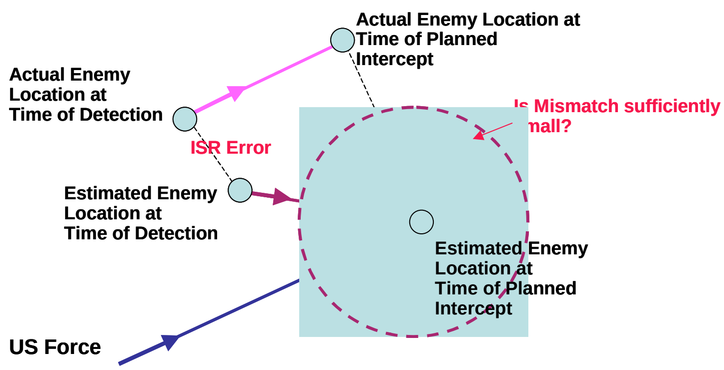

Figure C-2. Promptly Bring Forces to Bear

The better the information, the better is the capability to promptly engage the enemy. However, there is a limit to how much can be learned about enemy intentions, particularly if the enemy is

intent on deception. The model allows for an exploration of this limit by explicitly including the variance of the stochastic process describing the knowledge of enemy speed.

Figure C-3 illustrates the general concept behind the third model which evaluates a fleet's capability to fight from the sea. To model this capability, imagine that the fleet is confronted with enemy targets operating in some area, and that sensors and weapons are deployed. The sensors are an information-generating system designed to detect and localize as many of the targets as possible, and the weapons represent a killing system designed to destroy any target that has been detected and localized by the information-generating system. The model reflects the case where the number of targets to attack is much smaller than number of weapons at the fleet's disposal, a reasonable assumption given technical increases in fire-power in recent years and given that an asymmetric enemy would provide a target poor environment.

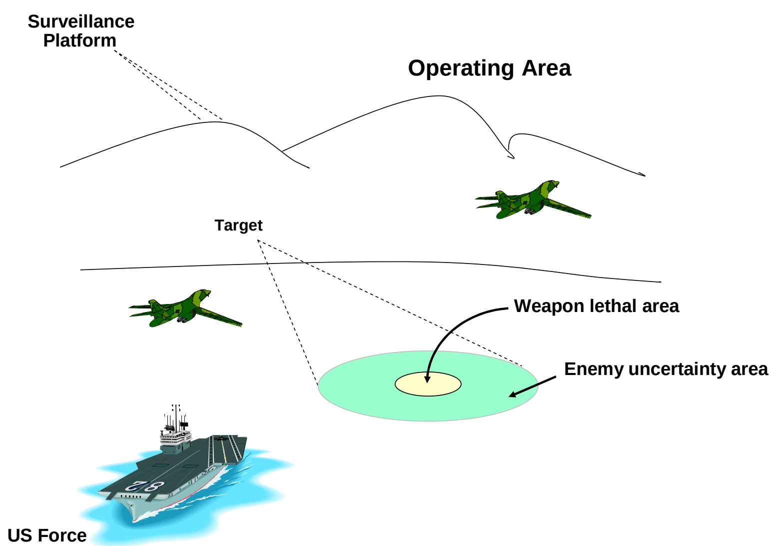

Figure C-3. Fighting from the Sea

We further consider the case where the targets have the ability to react to the information-gathering system's attempt to detect and localize them. Consequently, at any given time, targets fall into two classes: those that are under active localization and could be attacked with the higher precision corresponding to a well localized target, and those that are no longer under active localization but could still be attacked with much lower precision, a fleeing target. The model adds results of these two kinds of kills and evaluates the fleet's overall capability to fight from the sea as the fraction of targets it can destroy as a function of the enemy's ability to escape from the first class into the second. This ability to evade our track is a reflection of an asymmetric enemy.

Since the fleet's capability to develop and communicate knowledge of forces and situation reflects the degree of networking that exists between its elements, this model quantifies the increase in situational awareness provided by the network. The mechanism by which a network of elements gains more information than is available to the elements themselves is similar to a Bayesian process: the information provided by each element changes the prior state of

information available to the network into a posterior state. Consequently, the larger the number of contributing elements, the higher is the state of information about the battlefield available to the network. In particular, if the information sought is the location of some battlefield entity, the accuracy with which the network can determine that location is larger than the accuracy that each contributing element could attain, and the average location will be closer to the actual location. This is illustrated in **Figure C-4** where measurements conducted by each element in the network change the prior location distribution provided by indications and warnings into a posterior distribution whose mean is closer to the actual location than the prior and is significantly sharper. In fact, the variance of the posterior distribution decreases in inverse proportion with the square-root of the number of elements.

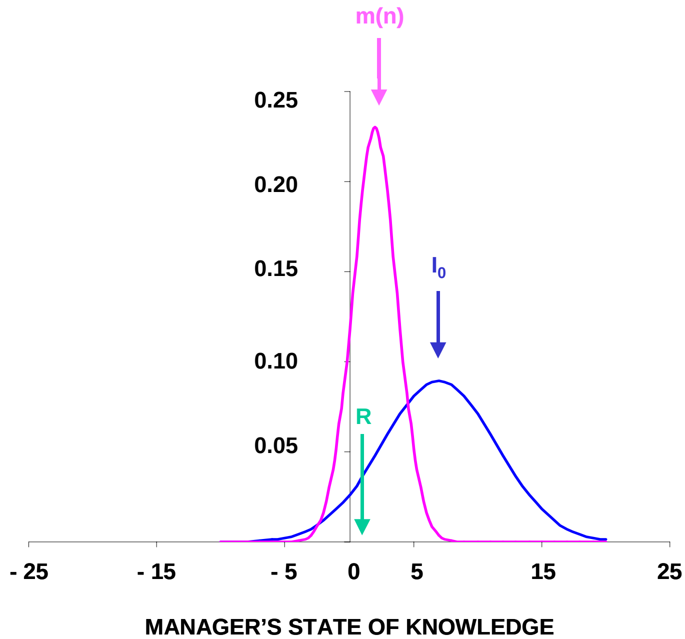

Figure C-4. Technical Contribution of Networking

Because networking is a fundamental feature of the fleet no matter what operation it performs, the results of this model have been incorporated into the results of all the models described above and will not therefore be displayed independently. We will, however, as described further down in the text, differentiate between two contributions that networking could provide: increase in the various technical capabilities of a fleet, and increase in the relevance of those capabilities to the kind of war being undertaken. The former will be quantified through the Bayesian process incorporated in the various capability models, the latter through a change in the degree of deception and evasion the enemy would be able to sustain.

Figure C-5 illustrates the concept of sustaining joint forces. In this case, land-based forces (Marines, Army, or allies) need immediate resupply from sea bases nearby. The means by which this sustainment occurs is via air that can fly rapidly and can overfly intervening difficulties and threats. Thus speed and cargo capability are the dominant characteristics sought in this operation. These would be MV-22s from amphibious ships in the programmed fleet or a large new-design gyrocopter flying from the X-SPT or X-WPS ships of the expeditionary strike group (ESG) in the alternative fleets.

Concept for
Sustain Joint Forces

- Unanticipated need arises for emergency resupply of embattled US or allied forces ashore (weather, enemy action, opportunity, etc)
- Forces call for supplies (ammo, fuel, water, etc)

	Program	Alternative
	MV-22	**Gyrocoptor**
Speed (kts)	250	350
Cargo (tons)	10	20

Figure C-5. Sustaining Joint Forces

Figure C-6 illustrates one concept of denying enemy the ability to hold the Homeland at risk. The surface ships assist the U.S. Coast Guard provide an interception barrier to interdict any craft, including very fast ones, attempting a sprint toward beach areas or ports. The density of interdiction craft and their speed relative to that of the intruder are the driving characteristics in this model.

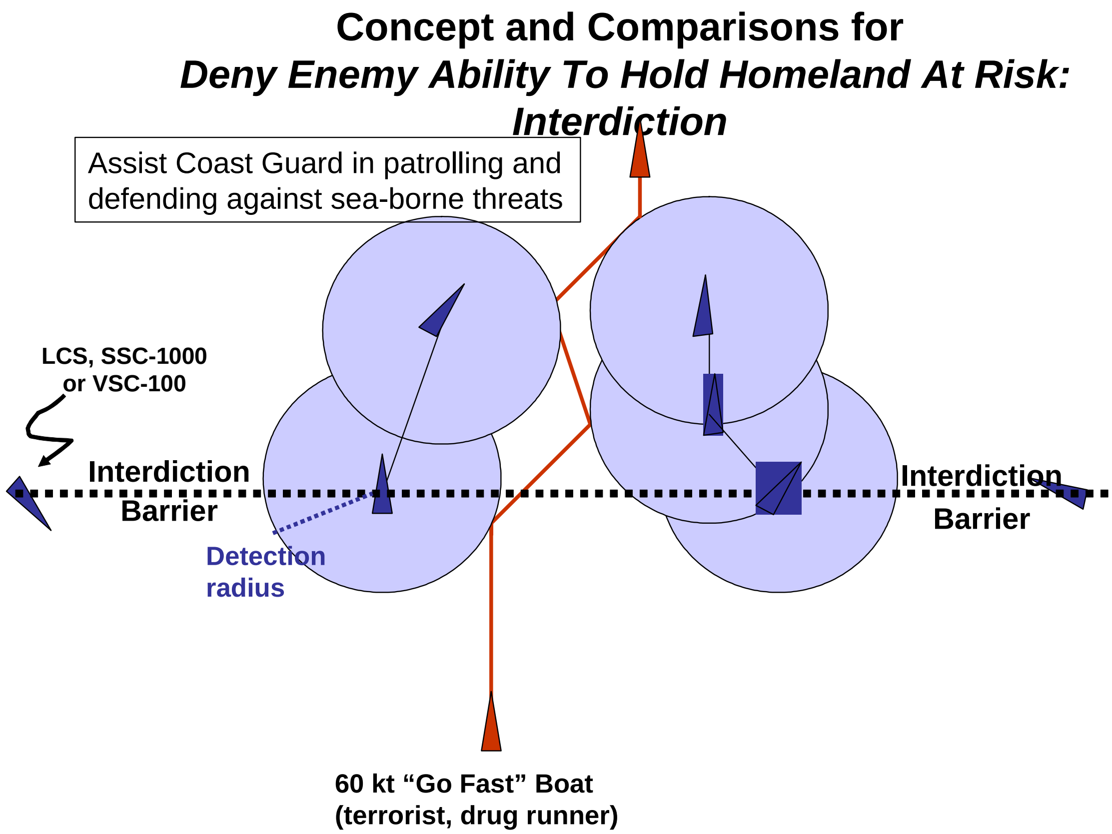

Figure C-6. Coastal Interdiction as Example of Denying Enemy Ability to Hold Homeland at Risk

A second concept for Homeland Defense is to employ naval ships as missile defenses around selected vulnerable or critical coastal areas of the United States. This concept is depicted in **Figure C-7**.

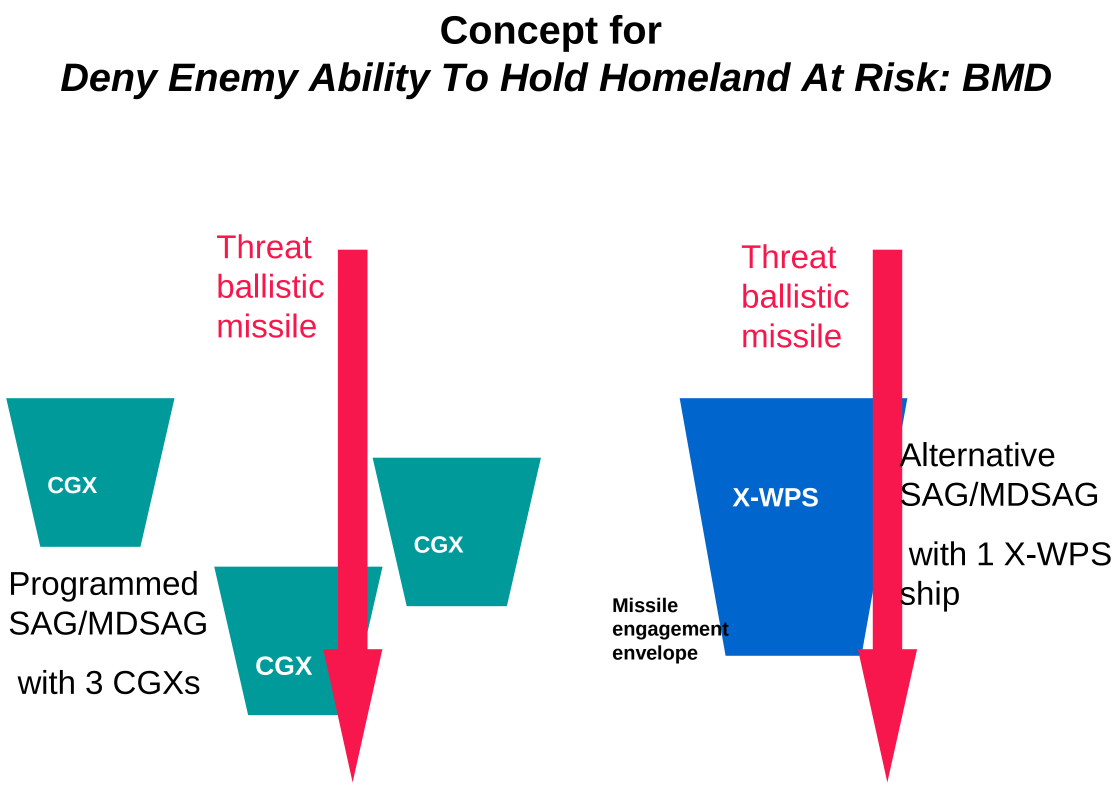

Figure C-7. Missile Defense as Example of Denying Enemy Ability to Hold Homeland at Risk